

Oren Walker

STATE OF NEVADA
DEPARTMENT OF HIGHWAYS

STANDARD
SPECIFICATIONS



1946 EDITION

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STATE OF NEVADA DEPARTMENT OF HIGHWAYS

STANDARD SPECIFICATIONS



1946 EDITION

No. 377

CARSON CITY, NEVADA

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DEPARTMENT OF HIGHWAYS

STANDARDS
SPECIFICATIONS



1948 EDITION

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CARSON CITY, NEVADA
STATE HIGHWAY DEPARTMENT
1948

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be interpreted to mean the test method or specification, as the case may be, and revisions thereof of the A. S. T. M. adopted and in effect on the date of invitation for bids.

1.3 **Advertisement.** The official notice inviting bids for all proposed work included in any one letting.

1.3 **A. S. T. M.** American Society for Testing Materials. Where the abbreviated citation "A. S. T. M. method" or "A. S. T. M. specification" followed by the appropriate method number or specification is used, it shall be interpreted to mean the test method or specification, as the case may be, and revisions thereof of the A. S. T. M. adopted and in effect on the date of invitation for bids.

1.4 **Bidder.** Any qualified individual, firm, or corporation submitting a proposal for the work contemplated, acting directly or through a duly authorized representative.

1.5 **Bridge.** Single or multiple span structures whose total span, measured horizontally along the center line of roadway between inside faces of end supports under the bridge seat or capstone, is greater than 20 feet.

1.6 **Calendar Day.** Any day shown on the calendar.

1.7 **Center Line.** The center of the roadway as laid out and staked by the engineer.

1.8 **Change Order.** A written order by the engineer to

PART I

GENERAL REQUIREMENTS AND COVENANTS

SECTION 1—DEFINITION OF TERMS

Whenever in these specifications, or in any documents or instruments in construction operations where these specifications govern, the following terms, or pronouns in place of them, are used, the intent and meaning shall be interpreted as follows:

1.1 A. A. S. H. O. American Association of State Highway Officials. Where the abbreviated citation "A. A. S. H. O. method" or "A. A. S. H. O. specification" followed by the appropriate method number or specification is used, it shall be interpreted to mean the test method or specification, as the case may be, and revisions thereof of the A. A. S. H. O. adopted and in effect on the date of invitation for bids.

1.2 Advertisement. The official notice inviting bids for all proposed work included in any one letting.

1.3 A. S. T. M. American Society for Testing Materials. Where the abbreviated citation "A. S. T. M. method" or "A. S. T. M. specification" followed by the appropriate method number or specification is used, it shall be interpreted to mean the test method or specification, as the case may be, and revisions thereof of the A. S. T. M. adopted and in effect on the date of invitation for bids.

1.4 Bidder. Any qualified individual, firm, or corporation submitting a proposal for the work contemplated, acting directly or through a duly authorized representative.

1.5 Bridge. Single or multiple span structures whose total span, measured horizontally along the center line of roadway between inside faces of end supports under the bridge seat or copings, is greater than 20 feet.

1.6 Calendar Day. Any day shown on the calendar.

1.7 Center Line. The center of the roadway as laid out and staked by the engineer.

1.8 Change Order. A written order by the engineer to

the contractor making changes in the plans or specifications which do not involve a change in contract unit prices. If the change involves items for which there is no contract unit price, the order shall so state and stipulate that they shall be performed as extra work.

1.9 Contract. The written agreement by the department and the contractor covering the performance of the work and the furnishing of labor and materials in the construction thereof. The contract shall include the notice to contractors, proposal, plans, specifications, special provisions, performance bond, and all supplemental documents as herein defined, amending or extending the work contemplated.

1.10 Contract Amount. The estimated contract cost computed on the basis of the proposal quantities and contract unit prices.

1.11 Contractor. The individual, firm, or corporation undertaking the execution of the work under the terms of the contract, acting directly or through a duly authorized representative.

1.12 Culvert. Waterway structures of spans less than the minimum spans defined for bridges.

1.13 Department. The Department of Highways of the State of Nevada.

1.14 Directors. The Directors of the Department of Highways of the State of Nevada as established by law, acting directly or through their authorized representatives.

1.15 Engineer. The State Highway Engineer of the State of Nevada, who is the executive officer of the Department of Highways, or an assistant or other representative duly authorized by the State Highway Engineer to act for him, such assistant or representative acting within the scope of the particular duties assigned him or of the authority given him.

1.16 Extra Work. Work or material, the performance or furnishing of which is found necessary for the proper completion of the improvement, but which is not covered by any item of the bid schedule and for which no means of payment, direct or indirect, has been provided in the contract.

1.17 Highway. The whole right of way which is reserved for use in constructing the roadway and its appurtenances.

1.18 Holidays. In the State of Nevada, these occur on:

January 1—New Year's Day

February 12—Lincoln's Birthday

February 22—Washington's Birthday

May 30—Memorial Day

July 4—Independence Day

First Monday of September—Labor Day

October 12—Columbus Day

October 31—Admission Day

November 11—Armistice Day

Thanksgiving Day

December 25—Christmas Day

or on a day on which the primary election is held throughout the State; or on a day on which a general or special State election is held; or on any day that may be appointed by the President of the United States or by the Governor of Nevada for public fast, thanksgiving, or holiday.

If any holiday listed above falls upon a Sunday, the following Monday shall be considered a holiday.

1.19 Inspector. An authorized representative of the engineer assigned to make any or all inspections of the work performed and materials furnished by the contractor.

1.20 Laboratory. The established laboratory of the department or other laboratory designated by the engineer.

1.21 Major Item. Any contract item, the total cost of which is more than five percent of the contract amount.

1.22 Notice to Contractors. The official notice included in the proposal inviting bids for the proposed work.

1.23 Performance Bond. The approved security furnished by the contractor to guarantee the completion of the work in accordance with the terms of the contract.

1.24 Plans. The approved official drawing of any and every kind, or reproductions thereof that show the work to be done.

1.25 Proposal. The approved prepared form on which the bidder has submitted in detail a statement of his offer to perform the work.

1.26 Proposal Guaranty. The required security submitted with the bid to insure the execution of contract and bond for the performance of the work if the bid is accepted.

1.27 Roadbed. That portion of the roadway between outside shoulder lines, including parapets or between the backs of curbs when constructed.

1.28 Roadway. That portion of the right of way required for construction.

1.29 Shoulder. That portion of the roadbed not occupied by the wearing course.

1.30 Skew Angle. The angle formed by the intersection of a line normal to the center line of the roadway with a line parallel to the face of the abutments, or in the case of culverts, with the center line of the culvert.

1.31 Special Provisions. Special requirements, regulations, or directions covering the proposed work on a particular project not satisfactorily provided for by these specifications.

1.32 Specifications. The directions, provisions, and requirements contained herein, supplemented by any special provisions as provided herein, pertaining to the method and manner of performing the work, to kinds, quantities, and qualities of materials to be furnished under the contract, and method of measurement and payment.

1.33 State. The State of Nevada.

1.34 Subgrade. That portion of the roadbed upon which curb and gutter, base course, or wearing course is to be placed.

1.35 Substructure. All of that part of the structure below the bridge seats or below the spring line of arches. Parapets and backwalls or abutments, and wing walls shall be considered as parts of the substructure.

1.36 Superintendent. The executive representative of the contractor, present on the work at all times during progress, authorized to receive and fulfill instructions from the engineer and to accept orders for changed and extra work.

1.37 Superstructures. All of that part of the structure

above the bridge seats or above the spring line of arches.

1.38 Supplemental Agreement. Written agreements executed by both parties to the contract to modify the contract to cover changes or changed conditions.

1.39 Surety. The individual, firm, or corporation signing, as guarantor, the performance bond furnished by the contractor.

1.40 The Work. All the work specified and prescribed by the specifications, special provisions, plans, and contract.

1.41 Working Day. Any calendar day, except as noted below, on which weather or ground conditions do not prevent utilization of at least fifty percent of the usual daily man-hours during regular working hours. Sundays and holidays shall be considered as working days only when the contractor performs work other than is necessary for the protection of the work and traffic.

SECTION 2—PROPOSAL REQUIREMENTS AND CONDITIONS

2.1 Plans and Proposal Forms. Qualified prospective bidders will be furnished with proposal forms which will give the location and description of the work contemplated, the time within which the work shall be completed, the amount of the proposal guaranty, the date, time, and place of opening proposals, and the schedule of items for which unit bid prices are asked, including the estimated quantities of work to be performed and materials to be furnished. All special provisions will be grouped together and attached to the proposal forms. All documents attached to the proposal shall be considered a part thereof and shall not be detached or altered.

Plans and proposal form (including special provisions) for individual projects may be obtained by qualified bidders. Request for plans and proposal form shall be made on the form furnished by the department and shall be accompanied by a deposit of \$10. A refund of \$5 will be made if the plans are returned in good condition within 15 days after opening of bids.

Plans and special provisions for individual projects may be obtained for inspection purposes by interested nonbidding concerns upon receipt of \$5. Requests for such plans need not be made on the standard form. Plans and specifications obtained on this basis are nonreturnable and no refund will be made.

2.2 Interpretation of Estimate. The quantities listed in the proposal are to be considered as approximate and as prepared are for the comparison of bids. Payment to the contractor shall be made for actual quantities of work performed or materials furnished in accordance with the contract, and it is understood that the quantities of work to be done and materials to be furnished may each be increased or decreased as hereinafter stipulated.

2.3 Examination of Plans, Specifications, Special Provisions, and Site of Work. The bidder shall examine carefully the site of, and the proposal, plans, specifications, and contract forms for the work contemplated. It will be assumed that the bidder has investigated and is satisfied

as to the conditions to be encountered; as to the character, quality, and quantities of work to be performed and materials to be furnished; and as to the requirements of these specifications, special provisions, and contract. It is mutually agreed that submission of a proposal shall be considered *prima-facie* evidence that the bidder has made such examination.

Information pertaining to exploration, borings, test pits, and other preliminary investigation may appear on the plans or in the special provisions. While such data will have been collected with reasonable care, there is no expressed or implied guaranty that conditions so indicated are exact or entirely representative of those actually existing. The bidder shall put his own interpretation on results of such investigations and satisfy himself as to the conditions to be encountered.

2.4 Preparation of Proposal. The bidder's proposal shall be submitted on the proposal form furnished by the department. The blank spaces in the proposal shall be filled in correctly, where indicated, for each and every item for which a quantity is given, and the bidder shall state the prices, written in ink, both in words and numerals for which it is proposed to do each item of the work contemplated. The bidder shall sign the proposal correctly. In case of discrepancy between the prices shown in words and in numerals, the price shown in words shall prevail.

2.5 Rejection of Proposals Containing Alterations or Irregularities. Proposals may be rejected if they contain alterations, additions not called for, conditional or alternate bids unless called for, incomplete bids, or irregularities of any kind. Proposals in which the prices obviously are unbalanced may be rejected.

2.6 Proposal Guaranty. No proposal shall be considered unless accompanied by cash or by a certified check or cashier's check, made payable to the department, in an amount equal to not less than five percent of the total amount of the bid.

2.7 Delivery of Proposals. Each proposal shall be placed, together with the proposal guaranty, in a sealed envelope so marked as to indicate the identity of the project and the name and address of the bidder. Proposals must be

received prior to the hour and date set for the opening thereof, and shall be by that time in the hands of the official indicated in the notice to contractors.

2.8 Withdrawal of Proposals. A proposal after being submitted may be withdrawn at any time prior to the time indicated for opening proposals, provided a written request therefor is filed by the bidder with the official designated to receive the proposals. The withdrawal of a proposal shall not prejudice the right of a bidder to file a new bid.

2.9 Public Opening of Proposals. Proposals shall be opened and read publicly at the time and place indicated in the notice to contractors. Bidders or their authorized agents are invited to be present.

2.10 Disqualification of Bidders. More than one proposal from an individual, a firm or partnership, a corporation or an association under the same or different names will not be considered. Reasonable ground for believing that any bidder is interested in more than one proposal for the work contemplated shall cause the rejection of all proposals in which such bidder is interested. If there is reason for believing that collusion exists among the bidders, bids of all of the participants in such collusion shall be rejected, and such participants may be disqualified from bidding on future work.

2.11 Competency of Bidders. All bidders shall be pre-qualified as required by law. Plans and proposal forms shall be issued only to prospective bidders who have been prequalified. To be qualified, a prospective bidder shall submit, under oath, on the standard form furnished by the department, a statement of his financial ability and experience in performing public work. Financial statements shall be prepared and certified by a certified public accountant or by an accountant who has been previously approved by the department as being competent to prepare a contractor's financial statement. After verifying the information contained in the statement, the department shall notify the submitter of the maximum contract amount and class of work upon which he will be eligible to bid.

Statements of financial ability and experience shall be submitted as of the date upon which the fiscal year of the

prospective bidder ends. In order to remain on the qualified list, a prospective bidder shall submit a new statement at the close of his fiscal year. A prospective bidder, not already qualified, shall submit his statement of financial ability and experience at least five full days prior to the date set for opening of bids in which he is interested in order to have it considered, but qualification shall not be granted until such statement has been verified. Statements shall preferably be submitted at least 30 days prior to bid opening.

Nothing contained in this section shall be construed as depriving the department of its discretion in the matter of determining the lowest responsible bidder.

2.12 Material Guaranty. Before any contract is awarded, the bidder may be required to furnish a complete statement of the origin, composition, and manufacture of any or all materials to be used in the construction of the work, together with samples, which samples may be subjected to the tests provided for in these specifications to determine their quality and fitness for the work.

2.13 Qualification of Bids. A bidder who desires to bid upon more than one project at a single letting, but who desires to protect himself against receiving the award of more projects than he is equipped to handle, may bid upon any number of projects, securing the protection desired by making the following written statement signed by the bidder and attached to the proposal form for each of the projects: "This bid is conditioned upon my (or our) receiving the award of contract for only one of the projects for which I (or we) have submitted bids at this letting. If the contract for any other project is awarded to me (or us), then this bid shall be considered withdrawn."

In case a bidder who has conditioned his bids, as above provided, is low bidder on more than one project, it shall be optional with the department as to which one of the projects is awarded him.

SECTION 3—AWARD AND EXECUTION OF CONTRACT

3.1 Consideration of Proposals. The proposals received will be compared on the basis of the summation of the products of the items of work listed and the contract unit prices offered. In case of discrepancy between the gross sum shown in the proposal and that obtained by adding the products of the quantities of work and the unit prices, the unit prices shall govern and any errors found in said products shall be corrected.

In the event the sum of the amount of the proposal and the sum of the amounts of work under contract and incomplete is in excess of the bidder's qualification established as provided in Article 2.11, the right is reserved to reject such proposal.

If proposals for more than one project are issued to a bidder, which projects individually would be within the bidder's qualification established as provided in Article 2.11, but a combination of more than one, considering also the work under contract and incomplete, would be in excess of his qualification, the right is reserved to consider only such proposal or proposals as in the opinion of the directors are within such rating and most advantageous to the State.

Until the final award of the contract, the right is reserved to reject any and all proposals and to waive technical errors, as may be deemed best for the interests of the State.

3.2 Award of Contract. The award of the contract, if it be awarded, shall be to the lowest responsible bidder whose proposal complies with all the requirements prescribed. The award, if made, shall be made within 30 days after the opening of the proposals.

3.3 Return of Proposal Guarantees. All proposal guarantees shall be returned immediately following the determination of the bid amounts, except those of the two lowest bidders. The proposal guarantees of these bidders will be returned immediately after a satisfactory performance bond has been furnished and the contract has been executed except when the proposal guaranty has been forfeited as liquidated damages as provided in Article 3.6.

3.4 Requirement of Performance Bond. The bidder to whom the contract is awarded shall file, as a guaranty that he will complete the work in accordance with the terms of the contract, a good and sufficient bond in an amount not less than the contract amount. Such bond shall also provide and secure payment for all materials, labor, provender and supplies, teams, trucks, and other means of transportation, used in, or upon, or about, or for the performance of the work contracted to be done, and for any work or labor done thereupon or incidental thereto. This bond shall be on the form provided by the department and shall be written by a surety approved by the Insurance Commissioner of the State of Nevada. A power of attorney for an attorney in fact who executes bonds shall be registered with, and approved by, the Insurance Commissioner of the State of Nevada. The power of attorney shall show the limiting amount authorized for issuance of bonds. Written appointment of agent of bonding company in and for the State of Nevada shall also be registered with, and approved by, the insurance commissioner.

3.5 Execution of Contract. The contract shall be signed by the successful bidder and returned, together with the performance bond, within 15 calendar days after the bidder has received notice that the contract has been awarded. No proposal shall be considered binding upon the department until the execution of the contract.

3.6 Failure to Execute Contract. Failure to execute a contract and file an acceptable bond, as provided herein, within 15 calendar days from date of receipt of notice of award shall be just cause for the annulment of the award and the forfeiture of the proposal guaranty to the department, not as a penalty, but as liquidated damages. Award may then be made to the next lowest responsible bidder, or the work may be readvertised and constructed under contract, or it may be performed otherwise as the engineer may decide.

SECTION 4—SCOPE OF WORK

4.1 Intent of Plans and Specifications. The intent is to prescribe a complete work of improvement which the contractor undertakes to do, in full compliance with the plans, these specifications, the special provisions, proposal, and contract. The contractor shall perform all items of work covered and stipulated in the proposal and perform changed and extra work, all in accordance with the lines, grades, typical cross sections, and dimensions shown on the plans, and shall furnish, unless otherwise provided in the special provisions or in the contract, all materials, implements, machinery, equipment, tools, supplies, transportation, and labor necessary to the prosecution and completion of the work.

4.2 Special Work. Proposed construction or requirements not covered by these specifications shall be covered by special provisions, and such construction or requirements shall be performed or complied with by the contractor as herein provided.

4.3 Changed Conditions. Should the contractor encounter, during the progress of the work, latent conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inhering in work of the character provided for in the plans and specifications, the contractor shall immediately notify the engineer thereof in writing. The engineer shall thereupon promptly investigate, and if he finds they do so materially differ, an equitable adjustment of the contract shall be made by means of a supplemental agreement. Claim for adjustment shall not be valid unless made in writing within 10 days after such latent conditions are encountered.

4.4 Changes in Plans and Specifications. The engineer reserves the right to make, by written order and without notice to surety, changes in the plans and specifications within the general scope of the contract.

The work as changed shall be performed by the contractor at contract unit prices, except when a change involves: (a) work materially different from the original; (b) an increase or decrease of more than 25 percent of the contract amount; (c) or an increase or decrease of more than 25

percent in the quantity of any major item, except items of overhaul, structure excavation, piling, concrete seal courses, water, rolling, and such other items as may be specifically excluded in the special provisions, or an increase or decrease in any minor item not excluded above of more than one and one-quarter percent of the contract amount.

Changes as indicated above under (a), (b), and (c) shall be made by means of a supplemental agreement, and if justified, both contract unit prices and contract time of performance may be adjusted. Adjustment of contract unit prices, if made, shall be based upon estimated change in unit cost of performance. Work shall not be started until the supplemental agreement has been signed by both parties.

Changes not requiring negotiated agreements, except as to extra work involved, shall be ordered by means of a change order, and acceptance by the contractor, as evidenced by his signature, shall constitute agreement that the change does not involve any adjustment of contract unit prices. Should the nature of the change order be such that the adjustment of contract time for completion as provided in Article 8.6 for increased quantities of work is not equitable, the engineer shall determine the additional time to be allowed, and such time shall be stated on the order. Work shall not be started on any such change until the change order has been delivered to the contractor and accepted by him.

In case the contractor refuses to accept a change order because he considers the change to involve an adjustment of prices, or agreement cannot be reached in regard to price adjustment for a supplemental agreement, the engineer may order the work to proceed and defer settlement of the disputed points.

4.5 Changes in Limits of Work. Changes in the limits of work may be made, without notice to surety, provided the aggregate of such changes is not more than 25 percent of the contract amount. A supplemental agreement shall be prepared to cover such changes, and the work shall not be started until the supplemental agreement has been signed by both parties to the contract.

4.6 Increased or Decreased Quantities of Work. In order to meet conditions encountered at the site, the engineer shall make minor adjustments of alignment, grade, earthwork slopes, the thickness of gravel base courses, or structure layouts, and such adjustments shall not be considered as changes in the plans as contemplated under Article 4.4. For this and other reasons, including unpredictable variations in earthwork shrinkage and slides, the exact final quantities cannot be determined at the time of advertising the work and, within the limits specified below, overruns and underruns from the quantities in the proposal shall be considered as normal and expected. The contractor shall perform such increased or decreased quantities without any adjustment of contract unit prices.

If demand is made by either contracting party, an adjustment shall be made in accordance with Article 4.3, under the following conditions:

- (a) If the actual quantities of all items show an overrun or underrun resulting in a change of 25 percent or more in the total cost of the work as compared with the contract amount.
- (b) If the actual final quantity of any major item, except overhaul, foundation excavation, compaction, piling, water, rolling, and such other items as may be specifically excluded in the special provisions, overruns or underruns more than 25 percent.

When justifiable, an adjustment shall be made in the contract unit prices when a supplemental agreement is required as prescribed in (a) and (b), provided that such adjustment shall be based upon estimated increased or decreased unit cost of performance.

Minor adjustments are defined as changes that do not materially affect quantities, that do not change the standard of design, and that do not require a change in plans. They shall be ordered in writing by the engineer.

4.7 Extra Work. Extra work shall be performed by the contractor, upon receipt of a written order to perform such work, in accordance with the specifications and as directed. Such order shall be on the standard extra work order form, except that when a change is also involved it may be included in the change order. The order shall state the

work to be done, the method of payment and the estimated total cost. The method of payment may be agreed unit prices, force account, or a combination of the two. Agreed unit prices together with the estimated quantities of each unit shall be shown. Orders involving force account work shall be detailed as required in Article 4.8.

Should the nature of the extra work be such that the adjustment of contract time for completion, as provided in Article 8.6 for increased quantities of work, is not equitable, the engineer shall determine the additional time to be allowed, and such time shall be stated on the order.

If it is found necessary during the progress of the work to exceed the total estimated cost by more than 15 percent, or to use equipment, materials, or items not listed in the order, a supplemental order shall be issued before such additional cost is incurred or such additional equipment or materials are used.

Acceptance of the order by the contractor, as evidenced by his signature, shall constitute his agreement to unit prices or rental rates indicated on the order as agreed prices or rates.

4.8 Force Account Work. When the proposal includes an item or items to be done by force account, or when a supplemental agreement or change order provides for doing certain work by force account, such work shall be performed upon receipt of a written order issued by the engineer. The order shall include the following details:

- (a) Statement of work to be done.
- (b) Estimated number of hours and estimated hourly wage for each class of labor.
- (c) Estimated number of hours and rental rate for all equipment and teams.
- (d) Amount and estimated cost of all materials.
- (e) Estimated total cost.

The rental rates shall be the contract rates if any, otherwise they shall be agreed rates. In case rental rates cannot be agreed upon, the engineer may so indicate on the order and use for estimate purposes what he considers a fair price, deferring for future settlement the final rates to be used.

If it is found necessary during the progress of the work

to exceed the total estimated cost by more than 15 percent, or to use equipment, materials, or items not listed in the order, a supplemental order shall be issued before such additional cost is incurred or such additional equipment or materials are used.

Acceptance of the order by the contractor, as evidenced by his signature, shall constitute his agreement to unit prices or rental rates indicated on the order as agreed prices or rates.

The plan of work to be followed, the equipment to be used, and the amount and class of labor to be employed shall be determined by the engineer.

4.9 Rights in and Use of Materials Found in the Work. The contractor, with the approval of the engineer, may use on the proposed construction suitable stone, gravel, or sand found in the excavation, and will be paid for the excavation of such materials at the corresponding contract unit price therefor, but he shall replace at his own expense with other acceptable material all that portion of the materials so removed and used as was contemplated for use in the embankments, backfills, approaches, or otherwise. No charge for materials so used shall be made against the contractor except the replacement herein provided for. The contractor shall not excavate or remove any material from within the highway right of way which is not within the excavation as indicated by the slope and grade lines, without written authorization from the engineer.

4.10 Final Cleaning Up. Before final acceptance, the contractor shall remove or obliterate, insofar as feasible, all objects or disturbances of the ground which mar the landscape and were caused by his operations, but which are not part of the improvement. This shall be required on all areas used or occupied by the contractor, regardless of right of way limits.

Rubbish, excess material, temporary structures, and discarded equipment shall be collected and burned, buried, or otherwise disposed of as directed by the engineer. Pits or trenches for equipment set-ups or camp sites shall be filled and the ground restored, insofar as feasible, to its original condition. Temporary haul roads shall be scarified and

bladed to blend with surroundings. Pits from which materials have been obtained shall be dressed and shaped to conform with the surrounding ground. Waste shall be removed from the tops of banks and placed in the bottom of the pit. Except on steep sidehills, the banks of pits shall be cut to not steeper than one to one slopes and trimmed reasonably smooth. On steep sidehills the banks shall be sloped to blend with the natural contours. Bottoms of pits shall be reasonably smooth and level. All other disturbances shall be removed or corrected as directed by the engineer.

SECTION 5—CONTROL OF THE WORK

5.1 Authority of Engineer. The engineer shall decide any and all questions which may arise as to the quality or acceptability of materials furnished and work performed; as to the manner of performance and rate of progress of the work; as to the interpretation of the plans and specifications; as to the acceptable fulfillment of the contract on the part of the contractor; as to compensation; and as to mutual rights between contractors. In case the contractor fails or refuses to carry out orders of the engineer within a reasonable time after receipt of such orders, the engineer shall have the right to perform such work as may be necessary to correct unsatisfactory conditions, and to deduct the cost of such work from sums due or to become due under the contract. Decisions of the engineer shall be subject to appeal to the Board of Directors, whose decisions shall be final and conclusive. Such appeal shall be in writing and shall be made within 10 days, but in the meantime the contractor shall diligently proceed with the work.

5.2 Plans and Working Drawings. The approved plans shall be supplemented by such working drawings as are necessary to control the work adequately. All authorized alterations affecting the requirements and information given on the approved plans shall be in writing. No changes shall be made of any plan or drawing after it has been approved by the engineer, except by direction of the engineer.

Working drawings for any structure shall consist of such detailed plans as may be required for the prosecution of the work and are not included in the plans furnished by the engineer. They shall include shop details, erection plans, masonry layout diagrams, and bending diagrams for reinforcing steel, approval of which by the engineer shall be obtained before any work involving these plans is performed. Plans for cribs, cofferdams, falsework, centering, form work, and other items may also be required, and shall likewise be subject to approval by the engineer.

Approval of working drawings of any kind by the engineer shall not operate to relieve the contractor of any of his responsibility under the contract for the successful completion of the improvement, nor for the accuracy of dimensions, details and quantities, or agreement of dimensions and details.

The contract price shall include the cost of furnishing all working drawings.

5.3 Conformity with Plans and Allowable Deviations. Finished surfaces in all cases shall conform to lines, grades, cross sections, and dimensions shown on the approved plans. The crown, or rise of the finished surface of the roadway from the curb or side line to the center line, shall be as shown on the typical cross section of the plans, except at intersecting highways or wherever, to insure correct drainage or for other reasons, changes may be directed. Such other deviations from the approved plans and working drawings, as may be required by the exigencies of construction, shall in all cases be determined by the engineer and authorized in writing.

5.4 Coordination of Plans, Specifications, and Special Provisions. These specifications, the plans, special provisions, and all supplementary documents are essential parts of the contract, and a requirement occurring in one is as binding as though occurring in all. They are intended to be cooperative, to describe and provide for a complete work. In case of discrepancy, figured dimensions shall govern over scaled dimensions; plans shall govern over specifications; special provisions shall govern over both specifications and plans.

Should it appear that the work to be done, or any of the matters relative thereto, is not sufficiently detailed or explained on the plans or in the specifications or special provisions, the contractor shall make written application to the engineer for such further explanations as may be necessary, and shall conform to the explanations given as part of the contract.

5.5 Cooperation of Contractor. The contractor shall be

supplied with copies of the plans, specifications, and special provisions, and shall have available on the work at all times at least one copy each of these plans, specifications, and special provisions. He shall give the work the constant attention necessary to facilitate the progress thereof, and shall cooperate with the engineer and with other contractors in every way possible. In case of a dispute arising between two or more contractors engaged on the same work, as to the respective rights of each under these specifications, the engineer shall determine the matters at issue and shall define the respective rights of the various interests involved, and his decision shall not in any way be a cause for claims for extra compensation by any of the parties.

The contractor shall at all times have a competent superintendent satisfactory to the engineer as his agent on the work. The superintendent shall have full authority to execute orders or directions of the engineer without delay, and to supply promptly such materials, tools, plant equipment and labor as may be required. Such superintendent shall be furnished irrespective of the amount of work sublet.

5.6 Construction Stakes. The engineer shall furnish and set construction stakes establishing lines and grades in road work, roadway and waterway center lines, and bench marks for bridge work, and shall furnish the contractor with all necessary information relating to lines and grades. In case of bridges, if requested by the contractor, the engineer shall furnish stakes determining the center lines of all piers, pedestals or abutments, together with stakes determining the angles of the wings or retaining walls. The contractor shall furnish, free of charge, all additional stakes, all templates, and other materials necessary for marking and maintaining points and lines given. The contractor shall construct the work in accordance with the engineer's stakes and marks, making use of them before they are disturbed, and shall be charged with full responsibility for conformity and agreement of the work with such stakes and marks. The contractor shall be held responsible for the preservation of all stakes and marks and if, in the opinion of the engineer, any of the stakes or marks have been carelessly

or willfully destroyed or disturbed by the contractor, the cost of replacing them shall be charged against, and shall be deducted from, the payment for the work.

5.7 Authority and Duties of Inspectors. Inspectors, employed by the department, shall be authorized to inspect all work done and all materials furnished. Such inspection may extend to all or any part of the work and to the preparations, fabrication or manufacture of the materials to be used. The inspector shall not be authorized to revoke, alter, or waive any requirement of the specifications. He shall be authorized to call the attention of the contractor to any failure of the work or materials to conform to the specifications and contract, and shall have the authority to reject materials or suspend the work until any questions at issue can be referred to and decided by the engineer.

5.8 Inspection. The contractor shall furnish the engineer with every reasonable facility for ascertaining at any time whether or not the work performed and materials used are in accordance with the requirements and intent of the plans, specifications, and contract. If the engineer so requests, the contractor shall, at any time before final acceptance of the work, remove or uncover such portions of the finished work as may be directed. After examination, the contractor shall restore said portions of the work to the standard required by the specifications. Should the work thus exposed or examined prove acceptable, the uncovering or removing and the replacing of the covering or making good of the parts removed shall be paid for as extra work, but should the work so exposed or examined prove unacceptable, the uncovering or removing and the replacing of the covering or making good of the parts removed shall be at the contractor's expense. No work shall be done nor materials used without suitable inspection by the engineer or his representative. Any work done or materials used without suitable inspection may, at the option of the engineer, be ordered removed and replaced at the contractor's expense. Failure to reject any defective work or materials shall not in any way prevent later rejection when such defect is discovered, or obligate the department to make final acceptance.

5.9 Removal of Defective and Unauthorized Work. All

work which has been rejected shall be remedied, or removed and replaced, in an acceptable manner by the contractor, at his own expense, and no compensation shall be allowed him for such removal or replacement. Any work done beyond the lines and grades shown on the plans or as given, except as herein provided, or any extra work done without written authority, shall be considered as unauthorized and at the expense of the contractor, and shall not be measured or paid for. Work so done may be ordered removed at the contractor's expense. Upon failure on the part of the contractor to comply forthwith with any order of the engineer made under the provisions of this article, the engineer shall have authority to cause defective work to be remedied, or removed and replaced, and unauthorized work to be removed, and to deduct the costs from any moneys due or to become due the contractor.

5.10 Final Inspection. Whenever the work provided and contemplated by the contract shall have been satisfactorily completed, the engineer shall, within 10 days after receiving notice of completion, unless otherwise provided, make the final inspection.

If the work is not acceptable to the engineer at the time of such inspection, he shall advise the contractor in writing as to the particular defects to be remedied before final acceptance.

If within a period of 10 calendar days after such notice of nonacceptability has been given, the contractor has not taken steps to complete the work speedily as outlined by the engineer, the engineer may without further notice and without in any way impairing the contract, make such other arrangements as he may deem necessary to have the work completed in a satisfactory manner. The cost of so completing the work shall be deducted from any moneys due or which may become due the contractor under the contract.

SECTION 6—CONTROL OF MATERIALS

6.1 Source of Supply and Quality of Materials. The source of supply of each of the materials shall be approved by the engineer before delivery is started. Representative preliminary samples of the character and quantity prescribed shall be submitted by the contractor or producer for examination and testing prior to use. Only materials conforming to the requirements of these specifications and approved by the engineer shall be used in the work. If, after trial, it is found that sources of supply which have been approved do not furnish a uniform product, or if the product from any source proves unacceptable at any time, the contractor shall furnish an approved material from other approved sources. No material which, after approval, has in any way become unfit for use shall be used in the work.

6.2 Local Materials. Possible sources of local materials may be designated in the special provisions and the grading analyses of samples shown. The quality of material in such deposits will be acceptable in general, but the contractor shall determine for himself the amount of equipment and work required to secure a finished product meeting the specifications, and whether blending with other local materials will be necessary. It shall be understood that it is not feasible to ascertain from samples an average grading analysis for an entire deposit, and that wide variations from the grading shown shall be considered as usual and to be expected. It shall also be understood that the engineer may order procurement of material from any portion of any area designated as a pit site, and may reject portions of the deposit as unacceptable.

When material deposits are not designated in the special provisions, the contractor shall provide sources of material acceptable to the engineer.

The contractor shall negotiate with owners of deposits from which any material is to be obtained and shall sign an agreement with the owner prior to removing the material. He shall pay all royalties accruing under such agreement and shall also furnish any necessary rights of way for haul roads. The department will endeavor to determine

ownership and royalty payments for deposits designated as possible material sources. This information, insofar as available, will be shown on the plans or in the special provisions, but it shall not be construed as relieving the contractor of his obligation to enter into an agreement with the deposit owner as required herein. One executed copy of the agreement shall be furnished the engineer.

In case a designated deposit fails to contain the quantity of acceptable material indicated in the special provisions, the contractor shall immediately notify the engineer in writing. The engineer shall thereupon investigate, and if his investigation shows that there is not a sufficient quantity of acceptable material, he shall designate an alternate deposit from which to obtain the deficit. In such case, an adjustment of compensation shall be made as provided in Article 9.6. If, however, the contractor elect to use a deposit other than the alternate designated, the adjustment shall be made as if the alternate deposit had been used.

The contractor may obtain material from deposits other than those designated, provided such material conforms to the specifications, will not result in any increase in the cost of the work or future work, and will not impair the appearance of the roadside more than if the material were taken from a designated deposit. Generally, deposits located within 500 feet of the center line will not be approved. The engineer assumes no responsibility for the quantity of acceptable material in such deposits.

6.3 Samples and Tests. The engineer may require any or all material to be subject to tests by means of samples or otherwise, as he may determine. The contractor shall afford such facilities as the engineer may require for collecting and forwarding samples and shall not make use of, or incorporate in the work, any material represented by the samples until all required tests have been made and the material accepted. The contractor in all cases, shall furnish the required samples without charge. Tests of material shall be made by the engineer in accordance with commonly recognized standards of national organizations, and such special methods and tests as are in use in the department laboratory.

6.4 Special Methods of Tests. (a) **Swell Test.** The swell test shall be made by preparing a sample of dried aggregate of sufficient size to make a compacted cylinder four inches in diameter and two inches in height, proportioning the various sizes of aggregate to conform to grading requirements of the product desired. Asphaltic material of the grade to be used in construction is added in an amount equal to the theoretical quantity required by the aggregate. Aggregate and asphaltic material are heated to a temperature within the range of field mixing temperatures and are mixed until all particles are coated and the color is uniform. The molding apparatus consists of a metal cylindrical mold to the outer surface of which is attached a rod for supporting the measuring device, a close-fitting cylindrical plunger for compressing the sample, a machined metal base plate, and a hardwood tamping rod. The mold has an internal diameter of four inches and is six inches in height. While still warm, the prepared sample is placed in the mold in two layers. Initial compaction is obtained by rodding each layer 25 strokes with the tamping rod. Final compaction is obtained by inserting the plunger, placing the apparatus in a suitable testing machine and subjecting the sample to an ultimate load of 1,000 pounds per square inch. After the mold with its contents has cooled to room temperature, the surface of the specimen is covered with distilled water to a depth of two and one-half inches and, after a lapse of 24 hours, any vertical expansion or swell is measured accurately to the nearest one-thousandth inch.

(b) **Stripping Test.** A weighed sample of the material is mixed with approximately five percent by weight of the asphaltic product proposed for use. If the asphaltic product is a liquid at normal atmospheric temperature, the mixture is then spread out in a thin layer and allowed to air season overnight.

A 50-gram sample of the mixture is separated as nearly as possible into individual fragments or small clumps and placed in a 250 cc. Erlenmeyer flask with 175 cc. of distilled water.

The flask and contents are then agitated by rotation at a slow speed for a period of five minutes at room temperature. At the end of this period the sample is examined for

evidence of film stripping and the observation recorded.

If little or no stripping has been noted at room temperature, the test is repeated for another five-minute period at 100° F., the water being maintained at the temperature by means of a water bath throughout the period of test.

If little or no stripping has been noted at 100° F. the test is then repeated at 120° F.

The test is not quantitative in nature and observations as to extent of stripping may vary with individual operators. It is therefore suggested that the following general classification be adopted for reporting observations at the end of each period of agitation:

1. No stripping.
2. Slight stripping.
3. Bad stripping.

If apparently 25 percent or more of the surface area of the aggregate particles has been stripped, the results shall be reported as bad stripping.

(c) Residue of Emulsified Asphalt at 325° F. The procedure followed shall be in accordance with the Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds, A. A. S. H. O. T-47, except that the determination of the residue shall be the average of three 50-gram samples heated for three hours in a dish or beaker not less than three inches in diameter and of sufficient depth to prevent overflow.

(d) Compaction Test. Maximum density shall be obtained from a series of compaction tests, each at a standard degree of compaction but at a different moisture content, plotting for each test the pounds of dry soil per cubic foot against its respective moisture content, and drawing a smooth curve through the resulting points. The peak of the curve represents the maximum density and the percentage of water at that point represents the optimum moisture.

The dry weight per cubic foot at a standard degree of compaction for a given moisture content shall be determined by oven drying a sample sufficient to fill the compaction cylinder to a height of 10 to 13 inches when compacted and thoroughly mixing with it the desired amount of water. Compaction is obtained by means of apparatus consisting essentially of a compaction cylinder three inches

in diameter, a tamping shaft weighing ten pounds graduated in inches and tenths, and a piston. The moistened soil is placed in the compaction cylinder in five approximately equal layers and each layer is consolidated by dropping the tamping shaft 20 times through a height of 18 inches. After the fifth layer is compacted, the piston is placed within the cylinder and given five additional blows of the tamping shaft. With the tamping shaft resting on the piston, the height of the compacted soil column is read from the figures on the graduated tamping shaft to the nearest one-tenth inch at a point level with the top of the tube. The dry weight per cubic foot of the compacted soil may then be read from a prepared table.

The dry weight per cubic foot in place shall be obtained by excavating a test hole, carefully saving and weighing all excavated material, determining the moisture content, and determining the volume of the hole by refilling it with a dry sand of a known weight per cubic foot.

The relative compaction of a given soil shall be obtained from the following formula:

$$RC = \frac{WP}{WC} \times 100 \text{ in which}$$

RC = relative compaction

WP = dry weight per cubic foot in place, and

WC = maximum density or maximum dry weight per cubic foot compacted to a standard degree of compaction.

(e) Stability Tests of Asphaltic Mixtures. Stability tests are made in a stabilometer consisting of a cylindrical container in the form of a hydraulic cell arranged to measure the magnitude of any pressure tending to deform the specimen while the specimen is being subjected to load. Test specimens are prepared by compacting a sample of bituminous treated material to approximate road compaction, using the asphaltic material and grading of aggregate proposed for use on the construction in the form of briquettes four inches in diameter and two and one-half inches high. The mixture should include all particles passing the one-inch sieve. Compacted specimens are placed in the cylinder at a temperature of 140° F. and subjected to pressure

in a standard testing press. The load is applied steadily to the specimen at a rate of five-hundredths inch per minute, and the horizontal pressure transmitted through the specimen is measured by the magnitude of the expansion against the cylindrical hydraulic cell. Stability values are compared at a test load of 400 pounds per square inch. Stabilometer readings are reported as stability in a scale ranging from 0 percent to 100 percent in which the zero percentage is material giving a stabilometer reading similar to that of a liquid, and 100 percent represents a solid giving no stabilometer reading under the applied load.

6.5 Storage of Materials. Materials shall be stored so as to insure preservation of their quality and fitness for the work. Stored materials shall be located so as to facilitate prompt inspection. That portion of the right of way not required for public travel may be used for storage purposes, and for placing of the contractor's plant and equipment only to the extent that vegetation will not be destroyed nor the landscape marred. Any additional space required shall be provided by the contractor at his expense. Materials shall not be stored upon the highway except as permitted by the engineer.

6.6 Defective Materials. All materials not conforming to these specifications shall be considered defective, and all such materials, whether in place or not, shall be rejected and shall be removed immediately from the work by the contractor at his expense, unless otherwise ordered by the engineer. No defective material, the defects of which have been subsequently corrected, shall be used until approval has been given. Upon failure on the part of the contractor to comply forthwith with any order of the engineer made under the provisions of this article, the engineer shall have the authority to remove and replace the defective material and to deduct the cost of removal and replacement from any moneys due or to become due the contractor.

SECTION 7—LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

7.1 Laws To Be Observed. The contractor shall keep himself fully informed of, and at all times shall observe and comply with, all Federal and State laws and local bylaws, workmen's compensation laws, ordinances, and regulations in any manner affecting the conduct of the work, and shall indemnify and save harmless the State and its representatives against any claim arising from the violations of any such law, bylaw, ordinance, or regulation, whether by the contractor himself or the contractor's employees.

7.2 Permits and Licenses. The contractor shall procure at his own expense all permits, licenses, insurance policies, etc., as may be necessary to comply with Federal, State, or local laws in the performance of the work.

7.3 Patented Devices, Materials, and Processes. It is mutually understood and agreed that, without exception, contract prices are to include all royalties and costs arising from patents, trade marks, and copyrights in any way involved in the work. It is the intent that whenever the contractor is required or desires to use any design, device, material, or process covered by letters patent or copyright, the right for such use shall be provided for by suitable legal agreement with the patentee or owner, and a copy of this agreement shall be filed with the engineer; however, whether or not such agreement is made or filed, the contractor and the surety in all cases shall indemnify and save harmless the department from any and all claims for infringement by reason of the use of any such patented design, device, material, or process, and shall indemnify the department for any costs, expenses, and damages which it may be obliged to pay, by reason of any such infringement, at any time during the prosecution or after the completion of the work.

7.4 Federal Participation. When the United States Government is to reimburse the department for any portion of the cost of the improvement, the work shall be subject to inspection and approval by appropriate agents of the

Federal Government; also in such cases the special provisions will set up certain requirements necessary to comply with the laws and regulations governing the Federal appropriation.

Inspection by representatives of the Federal Government and special provisions necessary to meet the requirements of the laws and regulations will in no sense make the Federal Government a party to this contract, constitute a waiver of any State law, or interfere with the rights of either party under the contract.

7.5 Restoration of Surfaces Opened by Permit. Upon the presentation of a duly authorized and satisfactory permit which provides that all necessary repair work will be paid for by the party to whom such permit is issued, the engineer may authorize the contractor to allow parties bearing such permits to make openings in the highway.

The contractor shall, when ordered by the engineer in writing, make in an acceptable manner all necessary repairs due to such openings, and such necessary work ordered by the engineer shall be paid for as extra work.

7.6 Sanitary Provisions. The contractor shall provide and maintain in a neat, sanitary condition such accommodations for the use of his employees as may be necessary to comply with the requirements and regulations of the Nevada State Department of Health or of other authorities having jurisdiction.

7.7 Public Convenience and Safety. The contractor shall be responsible for safely maintaining traffic over, through, or around the work included in his contract with the maximum practicable convenience to such traffic, whether or not work has ceased temporarily. If the contractor constructs temporary bridges or provides temporary stream crossings, his responsibility for accidents shall include the roadway approaches as well as the structures of such crossings. The work shall be planned and carried on so as to reduce obstruction to the traveling public to the minimum. No road shall be closed to the public by the contractor except by express permission of the engineer. When the

road under construction is being used by the traveling public, especial attention shall be paid to keeping the traveled way in such condition that the public can travel over it in comfort and safety. When so provided in the special provisions, structures, base courses, or pavements shall be constructed part at a time, with such lane or lanes maintained open to the public as required by the special provisions. The contractor shall at all times during the progress of the work, or temporary suspension of the work, provide, erect, and maintain all necessary barricades, suitable and sufficient red lights, danger signals, and signs, provide a sufficient number of flagmen, and take all necessary precautions for the protection of the work and safety of the public, and those engaged on the work. Highways closed to traffic shall be protected by effective barricades. Signs and barricades shall conform to the standards shown on the plans or approved by the engineer. All barricades and obstructions shall be illuminated at night with reflector signs and lights, and all lights for this purpose shall be kept burning from sunset to sunrise.

When traffic lanes are in any way restricted and it becomes necessary in the interest of safety to either the traveling public or the work to restrict materially the rate of speed of traffic, the contractor shall provide sufficient flagmen to slow down or bring to a stop all traffic prior to entering the danger zone. A pilot car and driver, in addition to flagmen, shall be provided by the contractor to conduct traffic through the danger zone when operations restrict traffic to movement in one direction at a time.

The contractor's responsibility for the maintenance of barricades, lights, and signs on the work or on individual sections of the work shall cease only upon final acceptance of the contract or upon acceptance of individual sections as provided in Article 7.11.

No direct payment shall be made for this work unless otherwise provided in the special provisions.

7.8 Use of Explosives. When the use of explosives is necessary for the prosecution of the work, the contractor

shall use the utmost care not to endanger life or property. All explosives shall be stored in a secure manner, in compliance with all Federal, State, and local laws and ordinances, and all such storage places shall be marked clearly "Dangerous—Explosives."

7.9 Preservation and Restoration of Property and Landscape. The contractor shall be responsible for the preservation of all public and private property, trees, vegetation, monuments, etc., along and adjacent to the roadway; shall use every precaution necessary to prevent damage or injury thereto; shall use suitable precaution necessary to prevent damage to pipes, conduits, and other underground structures and shall protect carefully from disturbance or damage all land monuments and property marks until an authorized agent has witnessed or otherwise referenced their location, and shall not remove them until directed. The contractor shall not injure or destroy trees or shrubs nor remove or cut them without proper authority. Insofar as feasible, the contractor shall confine his operations to the area within the limits of construction and not disturb the ground outside construction stakes. When or where any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect or misconduct in the execution of the work, or in consequence of the nonexecution thereof on the part of the contractor, such property shall be restored by the contractor, and at the contractor's expense, to a condition similar or equal to that existing before such damage or injury was done, by repairing, rebuilding, or otherwise restoring same, or he shall make good such damage or injury in an acceptable manner. If the contractor fails to carry out the provisions of this article the engineer shall have the right to have them carried out and deduct the cost from any moneys due or to become due the contractor.

7.10 Responsibility for Claims. The contractor and surety shall save harmless the department and all of its representatives from all suits, actions, or claims of any character brought on account of any injuries or damages sustained by any person or property, in consequence of any neglect in safeguarding the work, or through the use of unacceptable materials in the construction of the

improvement, or on account of any act or omission by the contractor or his agents.

The contractor guarantees the payment of all just claims for material, supplies, and labor, and other just claims against him, or any subcontractor, in connection with this contract.

The contractor, under these specifications, shall carry liability insurance to indemnify the public for injuries sustained by reason of the carrying on of his work.

7.11 Acceptance of Section of Highway for Maintenance. At the option of the engineer, certain sections of the work may be accepted for maintenance. In such cases, the sections shall be inspected, completed work tentatively accepted in writing at the discretion of the engineer, the maintenance of barriers, signs, and lights on the section discontinued, and the road opened to traffic and turned over to the department for maintenance. Such action shall not in any way be construed as a final acceptance of the road.

The contractor shall not be held responsible for damages to portions of the road which have been approved by the engineer and accepted for maintenance prior to final approval and acceptance of the road, provided such damages are due to action of the elements or to the ordinary action of traffic. The contractor shall be responsible for any damages occasioned by defective work, his own operations, or because of noncompliance with the plans, specifications, and contract.

7.12 Contractor's Responsibility for Work. Except as provided above, until the final acceptance of the work by the engineer as evidenced in writing, the contractor shall have the charge and care thereof and shall take every necessary precaution against injury or damage to any part thereof by the action of the elements or from any other cause, whether arising from faulty materials or work or from the execution or nonexecution of the work. The contractor shall rebuild, repair, restore, and make good all injuries or damages to any portion of the work occasioned by any of the above causes before its completion and acceptance, and shall bear the expense thereof, except damage to the work due to unforeseeable causes beyond the

control of and without fault or negligence of the contractor, including, but not restricted to, acts of God or the public enemy, acts of the State or Federal Government, slides found by the engineer to have been unavoidable, and ordinary wear and tear on any section of the road accepted for maintenance.

In case of suspension of work from any cause whatever, the contractor shall be responsible for all materials, and shall properly store them, if necessary, and shall provide suitable drainage of the roadway and erect temporary structures where necessary.

7.13 Personal Liability of Public Officials. In carrying out any of the above provisions or in exercising any power or authority granted to him by this contract, there shall be no liability upon the engineer or his authorized assistants, either personally or as officials of the State, it being understood that in such matters they act as the agents and representatives of the State.

7.14 No Waiver of Legal Rights. The department shall not be precluded or estopped by any measurement, estimate, or certificate made either before or after the completion and acceptance of the work and payment therefor, from showing the true amount and character of the work performed and materials furnished by the contractor, or from showing that any such measurement, estimate, or certificate is untrue or incorrectly made, or that the work or materials do not conform in fact to the contract. The department shall not be precluded or estopped, notwithstanding any such measurement, estimate, or certificate, and payment in accordance therewith, from recovering from the contractor and his surety such damages as it may sustain by reason of his failure to comply with the terms of the contract. Neither the acceptance by the department, or any representative of the department; nor any payment for the whole or any part of the work; nor any extension of time; nor any possession taken by the department shall operate as a waiver of any portion of the contract, or of any power herein reserved or any right to damages herein provided. A waiver of any breach of the contract shall not be a waiver of any other or subsequent breach.

SECTION 8—PROSECUTION AND PROGRESS

8.1 Subletting or Assigning of Contract. The contractor shall perform with his own organization and with the assistance of workmen under his immediate superintendence, work of a value not less than 80 percent of the value of all work embraced in the contract exclusive of items not commonly found in contracts for similar work, or which require highly specialized knowledge, craftsmanship, and equipment not ordinary available in the organizations of contractors performing work of the character embraced in the contract.

If any bidder shall state in his proposal the particular item or items of work which he proposes to sublet and shall name therein the subcontractor to whom he proposes to sublet such work in the event of an award to him, such item or items of work may be performed by such subcontractor notwithstanding the 80 percent limitation above mentioned, provided that the subcontractor named in the proposal is a contractor of recognized standing, has a record of satisfactory performance, and the work proposed to be sublet does not constitute the major item or items of work embraced in the contract. Any bidder who shall name a subcontractor in his proposal shall attach thereto a certificate that the use of the name of such subcontractor was with the knowledge and consent of such subcontractor. Any subcontractor so named in any bid may be required to submit questionnaires to establish his experience and financial ability. The naming of a subcontractor in any such proposal will not insure approval of the proposed subletting of work to him, and in the event of disapproval of such subletting, the contractor shall perform such item or items of work with his own organization, in full compliance with all applicable terms of his contract.

No portion of the contract shall be sublet, assigned, or otherwise disposed of except with the written consent of the engineer. Requests for permission to sublet, assign, or otherwise dispose of any portion of the contract shall be in writing and accompanied by a showing that the organization which will perform the work is particularly experienced and equipped for such work. The contractor shall

give assurance that the minimum wage for labor as stated in his proposal shall apply to labor performed on all work sublet, assigned, or otherwise disposed of in any way. Written consent to sublet, assign, or otherwise dispose of any portion of the contract shall not be construed to relieve the contractor of any responsibility for the fulfillment of the contract.

Roadside production of materials is construed to be the production of crushed stone, gravel, and other materials with portable or semiportable crushing, screening, or washing plants established or reopened in the vicinity of the work for the purpose of supplying materials to be incorporated into the work on a designated project or projects and in all cases, unless performed by the contractor, shall be considered as subcontracting.

The purchase of sand, gravel, crushed stone, crushed slag, batched concrete aggregates, ready-mixed concrete, and any other materials produced at and furnished from established and recognized commercial plants, together with the delivery of such materials to the site of the work by means of vehicles owned or operated by such plants or by recognized commercial hauling companies, shall not be considered as subcontracting under these provisions.

Except as hereinafter stated, all hauling of materials from roadside production sources, or from railroad or water delivery points, to batching plants, mixing plants, or directly to their place of use in the road, and all hauling of materials from batching plants and mixing plants to their place of use in the road, unless done by the contractor's own equipment or by recognized commercial hauling companies shall be considered as subcontracting under these provisions.

If batching plants or mixing plants are set up at rail or water delivery points and material in part supplied to such plants by rail or water transportation companies, the remaining materials required at such batching or mixing plants may be hauled to such plants without such hauling being considered as subcontracting.

8.2 Prosecution of the Work. The contractor shall begin the work to be performed under the contract, unless otherwise provided in the special provisions, not later than 20

calendar days after award of contract. At the beginning of construction, or at any subsequent suspension and resumption of work, the contractor shall notify the engineer at least 48 hours before beginning actual operations. He shall start the work at the part of the road designated by the engineer and shall prosecute the work at as many different points as the engineer shall direct.

The work shall be prosecuted diligently at such rate and with such materials, equipment, labor, and supervision as the engineer may consider necessary to insure its completion within the time set forth in the special provisions. When so ordered by the engineer, the contractor shall immediately provide such additional equipment, supplies, and labor as may be deemed necessary to complete the work within the required time.

On bridge contracts, within 15 days after award of contract, the contractor shall furnish the engineer with a working schedule, prepared in the form required by the department, showing in detail the estimated time of completion of the various parts of the structure.

8.3 Limitation of Operations. The contractor shall at all times conduct the work in such manner and in such sequence as will insure the least practicable interference with traffic; and he shall, when directed by the engineer, make use of convenient detours. He shall not open up work to the prejudice of work already started, and the engineer may require the contractor to finish a section on which work is in progress before work is started on any additional section.

The contractor shall so arrange his work and dispose of his material as not to interfere with the operations of other contractors engaged upon adjacent work, shall join his work to that of others in a proper manner and in accordance with the spirit of the plans and specifications, and shall perform his work in the proper sequence in relation to that of other contractors, all as may be directed by the engineer. Each contractor shall be held responsible for any damage done by him or his agents to the work performed by another contractor. Each contractor shall so conduct his operations and maintain the work in such condition that adequate drainage shall be in effect at all times.

8.4 Character of Supervision, Workmen, and Equipment.

The contractor shall at all times employ sufficient supervision, labor, and equipment for prosecuting the work to completion in the manner and within the time required by these specifications.

All workmen must have sufficient skill and experience to perform properly the work assigned them. All workmen engaged on special work or skilled work, such as bituminous courses or mixtures, concrete bases, pavements or structures, or in any trade, shall have had sufficient experience in such work to perform it properly and satisfactorily and operate the equipment involved, and shall make due and proper effort to execute the work in the manner prescribed in these specifications.

All equipment used on the work shall be of sufficient size and in such mechanical condition as to meet the time requirements, and produce work in conformity with these specifications. It also shall meet specific requirements set up elsewhere in these specifications for performing certain items of work.

No convict labor shall be employed and no materials manufactured or produced by convict labor shall be used in connection with the work. This provision shall not be construed as applying to convicts on parole or probation.

The contractor shall not discriminate against any worker because of race, creed, color, or national origin.

Any superintendent, foreman, or workman employed by the contractor or by a subcontractor who, in the opinion of the engineer or his authorized representative, does not perform his work in a proper and skillful manner or is disrespectful, intemperate, disorderly, or otherwise objectionable, shall at the written request of the engineer be forthwith discharged by the contractor or subcontractor employing such superintendent, foreman, or workman, and shall not be employed again on any portion of the work without the written consent of the engineer.

Should the contractor fail to remove such person or persons or fail to furnish suitable and sufficient machinery, equipment, or personnel for the proper prosecution of the work, the engineer may withhold all estimates which are

or may become due, or may suspend the work until such orders are complied with.

8.5 Temporary Suspension of Work. The engineer shall have the authority to suspend the work wholly or in part, for such period as he may deem necessary, due to unsuitable weather, or to such other conditions as are considered unfavorable for the suitable prosecution of the work; or for such time as he may deem necessary due to the failure on the part of the contractor to carry out orders given or to perform any provision of the contract. The contractor shall immediately respect the written order of the engineer to suspend the work wholly or in part. The contractor shall not suspend the work without permission of the engineer. The work shall be resumed when conditions are favorable and deficiencies have been corrected, as ordered or approved in writing by the engineer. No allowance of any kind will be made for suspension of work by order of the engineer, except as provided in Article 8.6.

8.6 Determination and Extension of Contract Time for Completion. The contractor shall perform the work in an acceptable manner within the time stated in the contract, except that the contract time for completion shall be adjusted as follows:

(a) If satisfactory completion of the contract shall require performance of work in greater quantities than those set forth in the proposal, the time allowed for performance shall be increased in the same ratio as the final estimate bears to the contract amount, and by such amounts as may be allowed under supplemental agreements and change orders as provided by Articles 4.3, 4.4, 4.5, and 4.6, or by extra work orders as provided in Article 4.7.

(b) In case of suspension of major items of work by order of the engineer and through no fault of the contractor, the time for completion shall be extended an amount equal to the elapsed time between effective dates of order to suspend and order to resume.

(c) When delays occur due to unforeseen causes beyond the control and without the fault or negligence of the contractor, including, but not restricted to, acts of God, acts of the public enemy, acts of the Government, fires, floods,

epidemics, strikes, and freight embargoes, the time for completion shall be extended an amount determined by the engineer to be equivalent to the delays; provided, however, written request for such extension of time is made by the contractor within 10 calendar days after the beginning of such delay. No allowance shall be made for delay or suspension of the work due to fault of the contractor.

8.7 Failure to Complete the Work on Time. If the contractor refuses or fails to complete the work within the time specified, including authorized extensions, there shall be deducted from the moneys due the contractor, not as a penalty but as liquidated damages, the sum named in the contract for each working day until the work is completed and accepted.

8.8 Annulment of Contract. Upon substantial evidence that the work does not conform to the plans and specifications, or of deliberate failure on the part of the contractor to comply with the terms of the contract, the engineer may proceed to annul the contract as follows:

The engineer shall advise the contractor in writing of his findings and require that the conditions complained of be corrected within a stated period of time.

If the contractor fails to correct the conditions cited within the period named, the department may annul the contract without further delay and take over the work and complete it by contract or otherwise, as the department may determine. The contractor and his sureties shall be liable to the department for any excess cost occasioned the department thereby. If a saving is made, it shall be paid to the contractor.

8.9 Termination of Contractor's Responsibility. The contract shall be considered complete when all work has been completed, the final inspection made, the work accepted by the engineer, and the final estimate paid. The contractor shall then be released from further obligation except as provided in Article 7.14.

SECTION 9—MEASUREMENT AND PAYMENT

9.1 Measurement of Quantities. After the work is complete and before final payment is made, the engineer shall make final measurement to determine the quantities of various items of work performed, as the basis for final settlement.

The contractor, in all cases, shall be paid for the actual amount of authorized work satisfactorily performed in accordance with the contract, as shown by the final measurement.

All work completed under the contract shall be measured by the engineer according to the United States standard measures.

All longitudinal measurements for area of subgrade, base courses, surface courses, pavement, and shoulders shall be made horizontally, and not along the actual surface of the roadway, and no deduction shall be made for fixtures in the roadway having an area of nine square feet or less. For all transverse measurements for area of subgrade, base courses, surface courses, pavements, and shoulders, the dimension to be used in calculating the pay area shall be the neat dimension shown on plans or ordered in writing by the engineer.

When the proposal calls for payment on a ton basis, the unit shall be the ton of 2,000 pounds. All materials which are specified for measurement by the ton shall be weighed on platform scales, except as noted below and except that gravel base, gravel surface, selected material surface, and imported borrow may be weighed on batch scales mounted below the bunkers. All scales shall be furnished by and at the expense of the contractor, shall be subject to the approval of the engineer, shall be located at points determined by the engineer, and shall be sealed at the expense of the contractor as often as the engineer may deem necessary to insure their accuracy. Platform scales shall be of sufficient size and capacity to weigh, in one operation, the entire loaded vehicle, except that this requirement may be waived by the engineer to permit the use of special hauling equipment with a wheel base longer than the commonly used platform scales. Waiver of this requirement, if made,

shall be in writing and subject to such conditions as the engineer deems necessary to insure sufficiently accurate weights.

Platform scales shall be equipped with a weatherproof housing so constructed as to protect the recording device and permit the weighmaster convenient access to all beams and dials. The housing shall be not less than 10 feet wide, 12 feet long, and seven feet high, and shall have two windows, one facing the scales, and shall be equipped with a shelf at least two feet wide and six feet long.

Approved vehicles for hauling may be of any type or size satisfactory to the engineer.

9.2 Scope of Payment. The contractor shall accept the compensation, as herein provided, in full payment for furnishing all materials, labor, tools, and equipment necessary to the completed work, and for performing all work contemplated and embraced under the contract; for loss or damage arising from the nature of the work or from the action of the elements, except as hereinbefore provided; for any unforeseen difficulties which may be encountered during the prosecution of the work, except as specifically exempted in Article 4.3, until the final acceptance by the engineer; for all risks of every description connected with the prosecution of the work; for all expenses incurred in consequence of the suspension or discontinuance of the work as herein specified; for any infringement of patent, trade mark, or copyright; for all expenses of maintaining completed portions of the work until final acceptance, except as provided in Article 7.11; and for completing the work according to the plans and specifications. Neither the payment of any estimate nor the payment of any retained percentage shall relieve the contractor of any obligation to make good any defective work or material.

It is understood and agreed that the accepted proposal for the contract is based on common carrier rates current on the date of the submission of the proposal. In the event such rates are increased thereafter on materials entering into and forming a part of the contract, such increase, when properly shown by received common carrier bills, shall be paid by the department to the contractor; provided, that should there be a reduction in the common carrier rates on

said materials, the amount of such reduction shall be deducted by the department from any moneys due the contractor on said contract.

9.3 Payment and Compensation for Changes in Plans or Quantities. When alterations in plans or quantities of work not requiring supplemental agreements are ordered and performed, the contractor shall accept payment in full at the contract unit price for the actual quantities of work done. Changes involving supplemental agreements shall be paid for as stipulated in such agreement.

9.4 Extra Work. Extra work shall be paid for in accordance with the accepted extra work order. Work specified in the order to be performed at agreed unit prices shall be paid for in the same manner as proposal items. Work specified and performed on a force account basis shall be paid for as specified in Article 9.5.

9.5 Force Account Work. Work specified and performed on a force account basis shall be paid for as follows:

(a) For all labor and foremen in direct charge of the specific operations, the contractor shall receive the same wage rates paid to these men, as evidenced by certified copies of the pay rolls, for the time they are actually engaged upon such work. Men employed on force account work shall receive the same rate of pay as they received when employed on contract items, or if the men have not previously been employed by the contractor, the rate shall be the same as for other similar labor. The contractor shall also receive reimbursement for workmen's compensation insurance and social security taxes paid on the labor employed. In addition to reimbursement for labor payrolls, workmen's compensation insurance, and social security taxes, the contractor shall receive an amount equal to 15 percent of the labor payroll cost.

The wages of any foreman or timekeeper who is employed partly on force account work and partly on other work, shall be prorated between the two classes of work according to the number of men employed on each class of work as shown by the pay rolls.

(b) For all materials entering into the work the contractor shall receive the actual cost of such material delivered

to the work, including freight and hauling charges as shown by original received bills, to which cost shall be added a sum equal to 15 percent thereof.

(c) For teams and equipment, the contractor shall receive the rental rate shown on the order for the time such teams and equipment are used on the work, except that in case estimated rates are shown the rate to be paid shall be the average cost of owning and operating equipment of the type used.

Equipment used on force account work and for which there is a contract unit price shall be paid for at the contract unit price for the particular kind of equipment used.

The compensation as above provided in (a), (b), and (c) shall be received by the contractor as payment in full for work done on a force account basis, including superintendence, overhead, use of small tools, profit, and incidentals.

The contractor and engineer, or authorized representative, shall compare records of pay rolls for labor furnished on force account basis at the end of each day; claims for work done on force account basis shall be submitted to the engineer by the contractor upon certified quadruplicate statements, to which shall be attached original received bills and invoices covering materials and freight and haulage charges on materials entering into such work. Such statements shall be filed not later than the twentieth day of the month following that in which the work was actually performed.

9.6 Adjustment of Haul on Local Materials. In case a designated material deposit is found to contain an insufficient quantity of satisfactory material as provided in Article 6.2, the contractor shall receive the following adjustment of compensation:

(a) Costs of moving the plant from the deposit which has failed to an alternate deposit and setting up the plant at the alternate deposit shall be paid for as extra work, except that no such payment shall be made when the alternate deposit is also a deposit designated in the special provisions.

(b) Additional haul caused by a change in designated deposits shall be paid for at the rate of seven cents per ton mile or 10 cents per cubic yard mile. The additional haul

to be paid for shall be the product of the number of tons or cubic yards of accepted materials and the additional haul distance. The additional haul distance shall be the number of miles or fractions thereof by which the distance from the new sources, designated by the engineer, exceeds the distance the same amount of material would have been hauled had it been obtained from the nearest of the deposits designated in the special provisions. Distances shall be measured between centers of mass, deposit source to the point of placement on the road over the shortest feasible route as determined by the engineer.

In case changes in thickness of base and surface courses result in increasing the average haul, the additional haul shall be measured, as provided below, and paid for as indicated above under paragraph (b). The additional haul distance shall be the number of miles or fractions thereof by which the average distance from the nearest designated sources to the points of actual placement on the road exceeds the average distance from the same sources to the points of placement indicated on the plans. Designated sources shall include those sources designated on the plans as well as other approved sources used by the contractor if a reduction in additional haul is accomplished by the use of such other approved sources. Additional haul to be paid for under this article shall be the net result of all changes in thickness made on the contract.

9.7 Omitted Items. The department shall have the right to cancel the portions of the contract relating to the construction of any item therein by the payment to the contractor of a fair and equitable amount covering all items of cost incurred prior to date of cancellation or suspension of the work by order of the engineer. In no case of this sort shall any allowance be made for anticipated profits.

9.8 Partial Payment. If satisfactory progress is being made, the contractor shall receive monthly estimates based on the amount of work completed during the preceding month. Progress estimates shall be based upon materials in place and labor expended thereon; but not more than 90 percent of the contract price of any work shall be paid in advance of full completion and acceptance; provided, however, that the engineer, at any time after 50 percent

of the work has been completed, if he finds that satisfactory progress is being made, may make any of the remaining partial payments in full. Should any defective work or material be discovered previous to the final acceptance, or should a reasonable doubt arise previous to the final acceptance as to the integrity of any part of the completed work, the estimate and payment for such defective or questioned work shall not be allowed until the defect has been remedied and causes for doubt removed. The monthly payments shall be approximate only, and all partial estimates and payments shall be subject to correction in the final estimate and payment.

9.9 Acceptance and Final Payment. The department shall make written final acceptance of the contract promptly after all work has been fully completed and final inspection made. As soon as practicable after final acceptance, the engineer shall furnish the contractor with the final estimate of quantities of work performed under the contract. The contractor shall examine such estimate and notify the engineer in writing of his agreement or file a specific claim covering disputed items. Failure on the part of the contractor so to notify the engineer or file a claim within a period of 30 days after receipt of the estimate shall be construed to signify the contractor's agreement to the quantities as set forth, and he shall have no further claim against the department, except as indicated in the final estimate of quantities. Final payment shall be due and payable at the expiration of not less than 30 calendar days nor more than 60 calendar days from the date of final acceptance.

PART II

CONSTRUCTION DETAILS

SECTION 10—ACCOMMODATIONS FOR PUBLIC TRAFFIC

10.1 Description. This item shall consist of providing accommodations for public traffic by detouring traffic over existing roads, by permitting traffic to pass through construction operations, by constructing and maintaining special detours, or by a combination of these methods as indicated on the plans or in the special provisions or as directed in writing by the engineer.

10.2 Materials. All materials required on the plans or in the special provisions, necessary for the construction and maintenance of facilities required for the free flow of public traffic, shall meet the requirements set forth elsewhere herein for the particular materials used.

10.3 General Requirements. Methods of handling traffic, if required, will be shown on the plans or in the special provisions.

The contractor shall make provisions for the free flow of public traffic at all times through those portions of the work, including special detours, where required. Access shall be permitted to residences, buildings, and driveways adjacent to existing roads, the road under construction, or special detours at all times and the contractor shall provide such temporary approach roads as may be required for this purpose.

At points where traffic is required to enter or cross the route of the contractor's hauling or other construction equipment, flagmen shall be stationed to slow and direct traffic.

In case of damage to detours due to storms or other causes, the contractor shall at once repair the damage or provide for carrying traffic through construction operations.

None of the provisions herein shall be construed to

restrict or prohibit, at any time, the prosecution of items of work which will not interfere with the use of the existing highway.

10.4 Carrying Traffic Through Construction Operations. Insofar as feasible, when traffic is to be carried through construction operations, grading shall be confined to part roadbed width at a time, the remaining width being used to accommodate traffic. At points where the depth of cut or fill on the existing road will not permit grading part width at a time without interfering with traffic, as much of the work as will not cause conflict between traffic and construction equipment shall be performed before destroying the existing roadbed. Grading operations shall then be alternated from one side of the roadbed to the other, keeping one side in good travelable condition and open to traffic. Culverts shall be installed and backfilled one-half width at a time, or at each structure the contractor may construct and maintain, at his own expense, short run-around detours acceptable to the engineer.

The graded surface and base courses shall be kept smooth and free from large rock at all times. Water shall be applied at points and in amounts as directed by the engineer to keep the roadbed firm, smooth, and stable, and reduce the dust hazard to a minimum.

Equipment shall be so operated that it will not unduly interfere with the flow of traffic. Where necessary for the protection of workmen or traffic, on short sections only, traffic may be limited to one way at a time, alternating directions. When one way traffic is in effect, a pilot car and driver shall be provided to escort traffic through the work, except where, in the opinion of the engineer, the distance is so short that flagmen at each end can properly direct traffic.

In all cases where traffic is carried through construction, flagmen shall be stationed at each end of each section upon which work is in progress to stop and direct traffic.

Whenever blasting which will interfere with, endanger, or delay traffic is necessary, operations shall be so conducted that traffic will not be delayed for periods longer than 20 minutes. Such blasting shall be done only during hours when the volume of traffic is at a minimum.

10.5 Passing Traffic Over Existing Roads. Where traffic is diverted over existing roads, approach roads from the new grade to the old road shall be provided to properly accommodate traffic. Such approach roads shall be constructed to a width comparable to the existing road and shall be constructed in a manner satisfactory to the engineer before beginning work on the corresponding section of new highway.

The existing road shall be widened and realigned as may be necessary to avoid conflict with the proposed new construction.

When windrowed material is left on the roadbed at night, such windrows shall be moved as far to one side of the roadbed as feasible, and the windrows shall be outlined with flares placed not more than 150 feet apart.

10.6 Special Detours. Special detours shall be constructed as shown on the plans or as specified in the special provisions. Detour locations indicated on the plans are approximate only; the exact locations shall be as staked by the engineer.

Grading for special detours shall consist largely of blade grader work, supplemented as may be necessary by other mechanical equipment, to provide the specified roadbed width and a grade line free from breaks or rolls of sufficient magnitude to be hazardous to traffic traveling up to 40 miles per hour.

When grading has been completed and approved by the engineer, special detours, if required on the plans or in the special provisions, shall receive surfacing materials of the kind and type specified, placed and constructed in accordance with the requirements for the particular materials used.

Water shall be applied to detours in amounts and at points as directed by the engineer to assist in the compaction of graded sections and of surfacing materials.

Maintenance on special detours shall consist largely of filling holes as they develop, adding surfacing, applying liquid asphalt, blading, watering, and performing any other work necessary to maintain the detour satisfactorily, all as ordered by the engineer.

Upon disturbing the existing roadbed corresponding to

a special detour, grading operations shall be prosecuted continuously to completion. Placing of gravel base or surface courses shall immediately follow completion of grading operations; and, in the case of gravel base course, bituminous prime coat shall be applied as soon thereafter as sections of sufficient length are available to permit the application of bituminous material in carload lots. The contractor shall permit traffic to travel over the primed or unprimed base course until such time as the remaining surfacing materials are being placed, at which time, traffic shall again be diverted over the special detours. If traffic is diverted over the unprimed base, water shall be applied at such points and in such amounts as to keep the roadbed firm, smooth, and stable, and reduce the dust hazard to a minimum.

After traffic has been turned over the completed new roadbed, temporary detour approach roads and those portions of special detours which are visible and unsightly from the new highway shall be removed and obliterated as directed by the engineer.

10.7 Signs. The contractor shall furnish, erect, maintain, and remove, as required by the engineer, signs and barricades of the designs and dimensions and at locations shown on the plans for the guidance of the traveling public.

Signs shall be substantially constructed of timber or heavy enameled metal. Timber signs and barricades shall be painted with not less than two coats of the required color and a top coat of spar varnish or shellac. All signs and barricades shall be fully reflectorized, as shown on the plans, and shall be substantially mounted at the required height.

Signs and barricades shall be maintained in first-class condition and any which may become scarred or damaged shall be repaired immediately or replaced as directed by the engineer. After completion of any portion of the work rendering continued use of the signs or barricades unnecessary, the contractor shall at once remove or change them, as directed by the engineer. All signs and barricades shall be the property of the contractor and shall be disposed of by him upon completion of the contract.

In addition to the signs and barricades required above,

the contractor shall furnish and erect, at his own expense, such other signs and safeguards as may be necessary to protect the public, workmen, and the work on account of his operations.

10.8 Alternate Methods. If the contractor desires to handle the work or traffic in a manner different from that outlined above, he shall submit in writing an outline of the plan he proposes. If, in the opinion of the engineer, such plan will provide for handling traffic in a satisfactory manner and at a cost which will not exceed the cost of providing for traffic as outlined above, permission may be granted to substitute the contractor's plan for the method set forth herein. Any changes made under these provisions shall be covered in writing on department change order forms.

10.9 Measurement and Payment. Reimbursement for all costs for carrying traffic through the work, including flagmen, excepting the application of water to lay dust, which shall be paid for at the contract unit price for that item, shall be considered as included in the contract prices for other items of the work.

If roadway excavation encountered in the construction of special detours or in the construction and removal of approaches to an existing highway, from the new to the old grade, is deemed sufficient to require mention on the plans or in the special provisions, such excavation shall be measured and paid for as specified under roadway excavation Section 14.

If the proposal contains an item for selected detour surfacing in lieu of other surfacing materials covered in these standard specifications, selected detour surfacing shall be measured in tons, or cubic yards, in the hauling vehicles at the point of loading, as indicated by the unit stated in the proposal form. Selected detour surfacing, measured as provided above, shall be paid for at the contract unit price per ton or cubic yard, as the case may be, which price shall be full compensation for stripping of pit, crushing, screening, loading, placing materials on roadbed, and compacting complete in place, except haul.

Haul on selected detour surfacing shall be paid for at the contract unit price per ton mile or yard mile, as the case may be, for "Haul on Selected Detour Surfacing."

Measurement of haul shall be from center of mass to center of mass along the shortest feasible route in miles and fractions thereof, without any deduction for free haul or any measurement by ton or yard station.

Liquid asphalt, if required to prepare a surface for special detours or for laying of dust, shall be measured as specified in Section 32 and paid for at the contract unit price for the particular type of material required.

All other work necessary for the construction and maintenance of special detours shall be paid for on a force account basis in accordance with Article 4.8, except that equipment for which there is a contract price shall be paid for at the contract unit price per hour for the particular item of equipment required. The estimated amount of equipment and number of hours of operation shall be as indicated in the proposal form.

The particular items of equipment indicated in the proposal form, or the equivalent thereof, in good mechanical operating condition shall be paid for at the contract unit price per hour for the particular item of equipment required. The contract unit price per hour for equipment shall include skilled operators for each piece of equipment, fuel, lubricants, repairs, depreciation, and all expense incidental to the operation of the equipment. The time allowed for such equipment shall be the actual time the equipment is in operation on the work.

The contract lump sum price for "Signs" shall be full compensation for furnishing, erecting, maintaining, changing, removing, and disposing of the signs and barricades and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

When roadmix detours are called for in the plans or in the special provisions, roadmixing shall be done in accordance with Section 37 or Section 38, whichever applies.

SECTION 11—CLEARING

11.1 Description. This item shall consist of clearing the areas designated of all trees, brush, logs, stumps, vegetation, and rubbish. It also includes grubbing and disposal of all materials resulting from clearing operations.

11.2 Areas To Be Cleared. The entire area to be occupied by the roadway shall be cleared to neat construction lines as staked by the engineer. Where rounding of the intersection of cut or fill slopes and the natural ground is required, clearing shall extend to the outer edge of the rounding. Where no rounding is required and cut slopes are steeper than two to one, clearing shall extend one foot outside neat roadway lines. Material deposits, ditches, and channels shall be cleared within neat excavation limits.

11.3 Construction Methods. Trees shall be felled within the area to be cleared in such manner as to avoid damage to vegetation outside this area. When the special provisions so require, merchantable logs shall be limbed, cut into commercial lengths, and placed in compact piles at points indicated on the plans or directed by the engineer. Likewise, firewood shall be limbed, cut into eight-foot lengths, split into convenient sizes for handling, and placed in compact piles at points indicated on the plans or directed by the engineer.

Stumps, roots, brush, and other embedded wood, shall be grubbed or blasted from the ground. Grass and weeds shall be cut flush with the ground surface.

Branches of trees overhanging the area to be occupied by the roadbed shall be cut where necessary to obtain a clearance of 14 feet above the finished surface, or where the engineer considers them likely to become a hazard to traffic.

Except as provided above, all vegetable matter resulting from the clearing operations and encountered within the area cleared, including leaves and duff, shall be piled and burned within the area cleared. In National Forest areas, burning shall be done in conformity with the regulations of the United States Forest Service, and in all cases the methods shall be such that there will be no damage to

vegetation outside the area to be cleared. Rubbish which cannot be burned shall be removed and buried or otherwise disposed of as directed by the engineer.

Before starting excavation the roadway area shall be completely cleared and grubbed, except that in cuts over three feet deep the grubbing may be done simultaneously with the excavation, provided satisfactory precautions are taken to insure that all roots and stumps are removed as the excavation proceeds, and do not become embedded in embankments or subgrade.

11.4 Method of Measurement. When the proposal includes an item for clearing, the quantity for which payment shall be made shall be the area in acres, computed on the basis of units 100 feet in length multiplied by the average width of each unit within the lines between which clearing has been required. Any such unit on which there is no clearing shall not be measured for payment. The measurement shall include the areas cleared as required for designated deposits from which borrow is obtained, but no measurement shall be made for necessary clearing of other material deposits.

If the proposal contains a separate estimate of quantities, individual trees more than six inches in diameter, three feet above the ground, shall be measured for payment as units, and all other clearing shall be considered as incidental to the various classes of earthwork.

11.5 Basis of Payment. When the proposal does not include an item for clearing, compensation for this work shall be considered as included in the contract unit prices for other items.

When the proposal includes a separate estimate of quantities, this item, measured as provided above, shall be paid for at the contract unit price per acre for "Clearing," which price shall be full compensation for furnishing all labor, material, tools, supplies, equipment, and incidentals necessary to complete the work.

When the proposal includes a separate estimate of quantities, trees ordered removed, and measured as provided above, shall be paid for at the contract unit price each for "Remove Trees," which price shall be full compensation

for furnishing all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work. This item shall not apply on any section on which the item "Clearing" is included.

SECTION 12—REMOVING STRUCTURES AND OBSTRUCTIONS

12.1 Description. This item shall consist of the removal and satisfactory disposal of all fences, buildings, structures, or other encumbrances as indicated on the plans or directed by the engineer.

12.2 Construction Methods. Fences, structures, and other obstructions which interfere with construction, or are shown on the plans, shall be carefully removed and any materials which, in the opinion of the engineer, may be satisfactory for use elsewhere, shall be salvaged and neatly stacked at accessible points as directed, and shall become the property of the department. Materials removed shall not be used on, or incorporated in, the work, unless otherwise specified, without written permission from the engineer. Unsalvageable material shall be disposed of by burning or depositing at points where it will not impair the appearance of the roadway.

Buildings shall be moved to new locations or demolished as indicated on the plans or ordered by the engineer. Buildings moved to new locations shall be placed on carefully graded sites and set upon foundations similar to the foundations on which the buildings rested. The contractor shall exercise every precaution in moving buildings to prevent them from being damaged and shall repair any damage which his operations may have caused. All power lines, water lines, sewers, and other appurtenances to the buildings shall also be moved and reconnected. When moved, buildings shall be in as good or better condition than before moving.

Existing structures, such as drainage pipes, bridges, culverts, and minor irrigation structures, or parts of such structures, shall be removed as noted on the plans or directed by the engineer. Pipe culvert headwalls shall be demolished in such manner that the ends of the pipe are not injured. Portions of structures ordered removed shall be removed in such manner that the part remaining is uninjured and may be utilized in the construction of a new structure. Unless otherwise shown on the plans, bridge

and culvert substructures shall be removed to a level at least one foot below the ground surface, except that if the remaining portion will interfere with the new work, the entire substructure shall be removed.

Removal of public utilities will ordinarily be performed by the company owning the property, but should the company involved fail to remove obstructions, such obstructions shall be removed or altered as directed by the engineer.

12.3 Method of Measurement and Basis of Payment. Payment for removal of structures and obstructions shall be made as follows:

If the proposal contains an item for removing fences, including gates, it shall be paid for at the contract unit price per linear foot for "Remove Fence." If there is no proposal item, removal of short sections of fence not exceeding 150 feet in length shall be considered as included in compensation for other items of the work; if any such section exceeds 150 feet in length, the removal of that section shall be paid for as extra work.

Demolishing of buildings shall be paid for at the contract unit price each or the contract lump sum price, as shown by the unit in the proposal, for "Remove Buildings." Moving of buildings shall be paid for at the contract unit price each or the contract lump sum price, as shown by the unit in the proposal, for "Move Buildings." In case there is no proposal item for demolishing or removing buildings, the work shall be paid for as extra work.

Removal of roadway and irrigation structures or other obstruction, or portions of such structures or obstructions, shall be paid for at the contract unit price each, the contract unit price per linear foot, the contract unit price per cubic yard, the contract lump sum price, or the contract unit price per square yard, as indicated by the unit for the particular type of structure or obstruction in the proposal.

Removal or alteration of public utility properties, underground pipes, and conduits, when ordered and no item is provided in the proposal, shall be paid for as extra work.

Removal of minor roadway and irrigation structures or embedded timbers or masonry for which there is no item

in the proposal shall be considered as incidental to roadway excavation, and compensation for such removal shall be included in the contract unit price for that item.

The compensation provided above shall be full payment for removing the obstructions, salvaging reusable materials, disposing of unsalvageable materials, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work, including necessary excavation and haul.

SECTION 13—DISPOSAL OF EXISTING SURFACE

13.1 Description. This item shall consist of the removal and satisfactory disposal of existing roadway surfaces, at points indicated on the plans or ordered by the engineer.

13.2 Construction Methods. Portland cement concrete, asphaltic concrete, and other similar pavements not suitable for reuse shall be broken up and disposed of by incorporating in embankments, or placing as directed by the engineer at points where the material will not impair the appearance of the roadside.

Gravel, roadmix, or plantmix surfaces suitable for reuse shall be removed to the depth required, and surfacing so removed shall be carefully salvaged and placed in compact stock piles at locations designated by the engineer. Care shall be exercised to prevent admixture of earth or other foreign materials, and sites of stock piles shall be leveled to avoid undue loss of material. These surfaces where not deemed by the engineer to be suitable for reuse shall be scarified and incorporated in embankments or subgrade.

13.3 Basis of Payment. Removal of Portland cement concrete, asphaltic concrete, and similar types of surfacing shall be paid for at the contract unit price per square yard for "Remove (type) Surface," for the actual number of square yards removed and disposed of satisfactorily.

Gravel, roadmix, or plantmix surfacing removed and placed in stock pile shall be paid for at the contract unit price per square yard for "Remove and Stock Pile (type) Surfacing," for the actual number of square yards satisfactorily removed and placed in stock piles.

Gravel, roadmix, and plantmix surfacing scarified and incorporated in embankments or subgrade shall be measured and paid for as roadway excavation.

Payment as provided above shall constitute full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to remove and dispose of existing roadway surfacing.

SECTION 14—ROADWAY AND DRAINAGE EXCAVATION

14.1 Description. This item shall consist of grading necessary for the construction of the highway, intersections, approaches, and waterways in accordance with these specifications, and to the lines and grades shown on the plans and staked by the engineer. It does not include borrow or imported borrow obtained either within or without the right of way limits, nor does it include structure excavation.

14.2 Classification. No classification of roadway excavation shall be made on the basis of materials encountered. Classification may be made by dividing the roadway transversely into sections and designating the classification within any section as "Roadway Excavation A," "Roadway Excavation B," etc. When such classification is made, the designation of each section shall be shown on the plans, and such designation shall not be changed regardless of the character of material encountered.

14.3 General Requirements. Before breaking the ground, clearing and grubbing shall be completed in accordance with Section 11 of these specifications. All excavation shall be made true to the lines and grades staked by the engineer, and except for a reasonable tolerance, the ground outside these lines shall not be disturbed.

All excavation shall be used in the formation of embankment, subgrade, shoulders, and dikes, unless otherwise indicated on the plans or ordered by the engineer.

14.4 Waterways. All ditches and channels indicated on the plans or ordered by the engineer shall be excavated true to lines and grades staked by the engineer. Suitable excavated material shall be disposed of by placing in roadway embankments or dikes as indicated on the plans or ordered by the engineer.

V-type ditches shall be excavated to the required cross section by means of suitable equipment which will deposit all of the loose material on the downhill side so that the bottom of the finished ditch shall be not less than two feet

below the crest of the loose material in the dike. Absolutely smooth ditches will not be required, but the flow lines shall be in satisfactory shape to provide drainage without overflow.

To avoid destruction of natural growth in the construction of ditches, channels, or dikes, travel of equipment shall be confined to the area within construction limits, except that turn-arounds may be permitted at points where they will not present an objectionable appearance from the roadway, and provided also that such turn-arounds shall not be located within 200 feet of the highway nor shall they be closer than 200 feet apart.

14.5 Rocks and Boulders. All rocks and boulders within construction limits shall be broken down to such size that they can be placed in the specified thickness of embankment layers, but in no case shall the contractor be required to break down rocks and boulders to sizes less than two feet in smallest dimension. If, after so breaking, they cannot be placed in embankments, they shall be disposed of as ordered by the engineer in such manner as not to mar the appearance of the roadside. If, in the opinion of the engineer, a more economical method of disposal is not available, they shall be placed in a trench excavated within the roadway for this purpose.

14.6 Solid Rock. If shown on the plans or ordered by the engineer, solid rock or other material requiring blasting shall be loosened and broken up so that no solid ribs, projections, or large fragments extend within six inches of the top of the staked grade. When ordered by the engineer, such material shall be removed and the space refilled with suitable material. Where feasible, as determined by the engineer, the material for refilling shall be obtained from roadway excavation.

Overbreak outside staked slope lines shall be removed and placed in embankments or otherwise disposed of as directed by the engineer. Overbreak below grade shall be refilled with suitable material at the contractor's expense up to within 12 inches of the top of the staked grade.

14.7 Blasting. Overshooting will not be permitted and the engineer shall have authority to require the contractor

to discontinue any method of blasting which results in breaking or loosening material outside of slope lines, or is dangerous, or is destructive to property or the landscape. The use of coyote holes in blasting is prohibited.

14.8 Slides. Slides extending beyond the staked slope lines shall be removed and placed in embankments or otherwise disposed of as directed by the engineer. The slopes shall then be cut to new lines established by the engineer for the purpose of eliminating, insofar as is feasible, any unsightly appearance caused by the slide.

14.9 Widening Cuts. When so ordered by the engineer, cuts shall be widened and cut slopes flattened over the widths and slopes originally staked, to obtain material for completing embankments.

14.10 Reserved Material. When, in the opinion of the engineer, certain material encountered in excavation should be reserved for finishing, such material shall be saved for this purpose. If feasible, this material shall be left in place until it can be hauled direct to where needed, but if this is not feasible, it shall be excavated, stockpiled, and later used for finishing.

14.11 Unsuitable Material. Soft or yielding material shall be excavated to the depth shown on the plans or ordered by the engineer, and the resulting space backfilled with suitable material. Sod shall be stripped from the area within construction limits and disposed of as indicated on the plans or directed by the engineer.

14.12 Slopes. All slopes, except in solid rock, shall be trimmed accurately to the lines staked by the engineer. The degree of smoothness shall be that normally obtained by hand shovel operations. A hand raked, "sand paper" finish is not required. Rock slopes shall conform as nearly as feasible to the required lines and shall be free from decided humps and holes. Such slopes shall be scaled and all loose material removed.

14.13 Method of Measurement. The volume of roadway and drainage excavation to be paid for shall be the number of cubic yards, measured in original position by the method of average end areas, of the following:

(a) Excavation within the lines, grades, and cross section indicated on the plans or staked by the engineer.

(b) Solid rock or other material requiring blasting actually removed to a depth not to exceed 12 inches below the elevation of the graded surface. No measurement shall be made of material broken up, but not removed, nor of any material removed if the space is backfilled before the engineer makes the necessary measurements.

(c) Overbreak (breakage of slopes outside of neat lines due to blasting) when not caused by improper methods of the contractor, in an amount equal to 50 percent of that actually occurring.

(d) Slides (breakage outside of neat slope lines due to the action of the elements or inability of the material to stand on the slopes constructed) when not caused by improper methods of the contractor.

(e) Excavation of soft or yielding material below grade where ordered by the engineer.

(f) Stock piles of reserved material without any deduction from the volume of the roadway prism from which they were obtained.

All excavation for ditches and channels having a bottom width of less than eight feet shall be classified as drainage excavation. All excavation for ditches and channels having a bottom width of eight feet or more shall be classified as roadway excavation. There shall be no distinction in classification on account of placing ditch or channel excavation either in dikes or within the roadway prism.

V-type ditches shall be measured in linear feet of ditch and each 100 feet shall constitute a unit of one station. The volume of excavation for such ditches shall not be measured.

14.14 Basis of Payment. The quantity, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Roadway Excavation," "Roadway Excavation A," "Roadway Excavation B," "Drainage Excavation," etc., as the case may be, and at the contract unit price per station for "V-type Ditches." Haul in excess of the free haul specified shall be paid for at the contract unit price for overhaul as provided in Section 18. When cuts

are ordered widened or slopes flattened after excavation has been made and sloping completed to the original stakes, any necessary additional hand shaping shall be paid for as extra work.

Clearing shall be measured and paid for as specified in Section 11.

The above payments shall constitute full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 15—BORROW

15.1 Description. This item shall consist of excavating and placing in the subgrade, embankments, or protection dikes, true to lines and grades, material from deposits or pits outside the roadway.

15.2 Materials. Borrow shall be material free from vegetable or other deleterious matter which, in the opinion of the engineer, will form a firm, stable roadbed. It shall be obtained from deposits indicated on the plans or in the special provisions, or designated by the engineer.

15.3 Construction Methods. No borrow pit shall be opened until all other excavation items are complete to the extent necessary to determine the need for borrow. It shall not be assumed that borrow indicated on the plans will be necessary in the amounts indicated, and no such borrow shall be made until it is evident there will not be an unexpected surplus from roadway excavation that should be used in lieu of such borrow. No borrow pit shall be opened until the engineer has staked it and authorized the contractor to enter it.

All materials unsuitable for embankment shall be rejected at the pit and disposed of as directed by the engineer. The excavation shall be made to the lines and grades staked by the engineer, which shall be such as to present a neat appearance and, where necessary, to properly drain the pit.

After completing the borrow, the pit shall be finished as required in Article 4.10.

15.4 Method of Measurement. The volume of borrow to be paid for shall be the number of cubic yards, measured in original position by the method of average end areas, of material acceptably excavated, including unsuitable material disposed of as directed by the engineer. Deduction shall be made for material placed outside staked lines of embankment.

15.5 Basis of Payment. When the proposal does not include an item for borrow, the quantity of borrow, determined as provided above, shall be added to, and for purposes of payment shall be considered as roadway excavation.

When such an item is included in the proposal, the quantity measured as provided above, shall be paid for at the contract unit price for "Borrow," which price shall be full compensation for furnishing all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

Haul in excess of the free haul shall be paid for as provided in Section 18.

Clearing shall be measured and paid for as specified in Section 11.

SECTION 16—IMPORTED BORROW

16.1 Description. This item shall consist of excavating and placing in embankments material from approved deposits, in accordance with these specifications and in conformity with the lines, grades, and cross section shown on the plans or designated by the engineer.

16.2 Material. The material shall consist of suitable embankment material obtained from deposits indicated on the plans or in the special provisions. Specific requirements will be set up in the special provisions to obtain the best available material for embankment; and, when necessary, a porous embankment material that will prevent or retard capillarity shall be used.

16.3 Construction Methods. Unsuitable overburden shall be stripped to the required depth and disposed of as directed by the engineer. The imported borrow shall be excavated to the lines and grades set by the engineer and shall be placed in embankment or subgrade in accordance with the requirements of Section 14 for roadway excavation and Section 19 for embankments.

16.4 Method of Measurement. The quantity to be paid for shall be the number of tons or the number of cubic yards measured in original position by the method of average end areas of suitable material acceptably placed within lines and grades staked by the engineer. The measurement shall not include unsuitable overburden, and deduction shall be made for material placed outside lines and grades.

16.5 Basis of Payment. The quantity, measured as provided above, shall be paid for at the contract unit price per ton or per cubic yard for "Imported Borrow," which price shall be full compensation for all labor, materials, tools, supplies, equipment, and incidentals, including clearing, grubbing, and stripping the pit, and for all haul required to complete the item.

SECTION 17—ROUNDED AND TRANSITION SLOPES

17.1 Description. This item shall consist of rounding and shaping slopes, when required, in accordance with the typical sections shown on the plans or ordered by the engineer.

17.2 Construction Methods. Cut slopes shall be rounded by excavating the tops of cuts to blend the cut slopes with the slope of the adjacent natural terrain. Embankment slopes shall be rounded by filling the bottoms of the embankments to blend the fill slope with the natural ground surface. Where cuts and fills intersect, the slopes shall be warped by flattening the ends of cuts and fills to blend more naturally the adjacent portions of the cut and fill.

Slopes will be staked for flattening and rounding in places where the material is other than solid rock, except that rock such as decomposed sandstone and granite that decomposes to such an extent that it will have the same appearance as earth, shall have the slopes flattened and rounded the same as earth slopes. A layer of earth overlying a rock cut shall be rounded above the rock the same as earth slopes. Where the depth of cut or fill is insufficient to provide the full rounding required, the distance for rounding shall be proportionately adjusted.

The degree of smoothness required in rounding and warping slopes shall be as specified for trimming cut slopes in Section 14. Slope rounding and warping shall also apply to drainage ditches when such rounding will improve the appearance of the roadside.

The contractor shall not operate mechanical equipment outside staked limits in the prosecution of the work contemplated under this item.

17.3 Method of Measurement. The quantity of rounded or transition slope to be paid for shall be the number of stations one hundred feet in length, treated as specified, in the completed and accepted work, measured along the center line of the roadway or ditch. Rounding of shoulders or bottoms of side ditches, when required, shall not be measured for payment.

17.4 Basis of Payment. The quantity, measured as provided above, shall be paid for at the contract unit price per station for "Slope Rounding," which price shall be full compensation for furnishing all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

In addition to the payment specified above, the quantity of excavation required shall be measured and paid for at the contract unit price for the particular item of earthwork involved.

SECTION 18—OVERHAUL

18.1 Description. This item shall consist of the transportation of roadway excavation and borrow when the gross haul exceeds the free haul. The limit of free haul shall be fixed at 500 feet.

18.2 Method of Measurement. When separate payment is provided, overhaul shall be measured by the yard station or by both the yard station and the yard mile. A yard station shall be one cubic yard hauled 100 feet. A yard mile shall be one cubic yard hauled one mile. Computation of overhaul shall be made by means of a mass diagram when practicable.

Except as provided below, measurement shall be made by the yard station and the overhaul distance shall be the distance, less 500 feet, between the center of volume in original position and the center of volume after placing. The number of yard stations shall be the product of the volume of the overhauled material, measured in its original position, and the overhaul distance.

When proposal items are included for both yard station and yard mile overhaul, overhaul for the first 1,000 feet shall be measured in yard stations as specified above. In addition, overhaul on the portion of the gross haul in excess of 1,000 feet shall be measured in yard miles and the overhaul distance shall be the distance, less 1,000 feet, between the center of volume in original position and the center of volume after placing. The number of yard miles shall be the product of the volume of the overhauled material, measured in its original position, and the overhaul distance.

Gross haul shall be measured along the center line of construction in the case of roadway excavation and along the shortest feasible route as determined by the engineer in the case of borrow.

Overhaul shall be computed only on the volume of acceptable roadway excavation and borrow paid for as specified in Sections 14 and 15.

18.3 Basis of Payment. Unless an item is included in the proposal, the contract unit price per cubic yard for roadway excavation or borrow shall be considered as including payment for overhaul.

If the proposal contains a separate estimate of quantities, this item, measured as provided above, shall be paid for at the contract unit price per yard station for "Overhaul, Yd. Sta.," or the contract unit price per yard station for "Overhaul, Yd. Sta.," and the contract unit price per yard mile for "Overhaul, Yd. Mi.," as the case may be, which price or prices shall be full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 19—EMBANKMENTS

19.1 Description. This item shall consist of constructing embankments or fills in accordance with these specifications and in conformity with the grades and cross sections shown on the plans or ordered by the engineer.

19.2 Materials. Embankments shall be constructed with acceptable materials excavated under any item of earthwork, except that when shown on the plans or ordered by the engineer, embankments shall be constructed with materials conforming to the specification for the particular item of earthwork shown or ordered. Materials used for embankments shall be free from vegetable matter, soft, spongy, frozen, or other objectionable materials.

19.3 Sequence of Operations. Except as noted below, bridges and culverts shall preferably be completed in advance of grading operations. If not so completed, a sufficient length of embankment, as determined by the engineer, shall be omitted on each side of such structures to permit proper compaction of the embankment adjacent to the structure, in accordance with these specifications, after the structure has been completed. Embankments over and around bridges and culverts shall consist of materials placed as specified under Section 21. Where required on the plans or by the special provisions, or when ordered by the engineer, embankments shall be constructed to a height of one foot above the top of pipe culverts before placing the pipe.

19.4 Foundation. Where indicated on the plans or ordered by the engineer, sod and soft or spongy materials shall be removed from the area to be covered by the embankment and shall be disposed of as shown on the plans or ordered by the engineer.

Frozen excavation material or a blanket of snow shall be considered cause for suspending grading operations.

19.5 Placing. Fine material suitable for finishing shall be placed on top. Clods or hard lumps over six inches in greatest dimension shall be broken up. Rocks or lumps of hardpan, cemented gravel, or similar material which cannot be broken readily shall be distributed throughout

the embankment and filled around with fine material so as to produce a dense compact embankment. If the plans show solid rock cuts to be excavated or broken up six inches below the graded surface as provided in Article 14.6, no rocks or hard lumps shall be placed above lines six inches below the finished graded surface of embankments.

No sod shall be placed in embankments within the roadbed, but it may be placed in the toe of the slope if uniformly distributed. Where ordered by the engineer or shown on the plans, sod shall be hauled and distributed uniformly over slopes of rock embankments.

When embankments are formed of rock, the material shall be carefully placed so that all large rock will be well distributed and the interstices shall be completely filled with smaller rock and earth, so as to form a dense, solid embankment.

All clay, adobe, or other high shrinkage materials placed in embankments shall be deposited at the bottom of the fill and no such material shall be placed above a point two feet below finished grade.

Except as indicated herein, embankments shall be placed and compacted in successive, full width layers. Sidehill embankments shall be constructed with the intersection at original ground as the low point of the layer and sloping uniformly to the outer side.

Embankments built of earth, gravel, or small particles of rock, which contain by volume less than 25 percent of rocks or boulders larger than six inches in greatest dimensions, shall be constructed in layers not more than eight inches in thickness before compaction. Each layer shall be compacted as required elsewhere herein.

Embankment material containing by volume 25 percent or more of rock too large to be placed and compacted in eight-inch layers shall be placed in layers of a thickness not exceeding the maximum size of the rock present in the material, but in no case shall the thickness of any layer exceed three feet. Sufficient earth or other fine material shall be incorporated with the coarse rock as it is deposited, to fill the interstices and provide a dense solid embankment. Each layer shall be compacted by routing the loaded hauling equipment over the entire width, supplemented by

the use of rollers. Rollers with tamping studs shall not be used to compact rock embankments.

When embankments are to be constructed on hillsides, or where new fill is to be placed against existing embankments, or where new fills are to be built one-half width at a time, the slopes of the original hillside, old or new fill shall be cut into as the embankment is brought up in layers. Material thus cut into shall be recompacted with the new fill at the contractor's expense, unless the width of cut required by the engineer exceeds four feet, in which case the excavated material shall be measured and paid for as roadway excavation.

Where embankments are to be constructed on original hillside, old or new fills, and end dumping is permitted, the slopes of the original ground, or fill, shall be plowed or benched before filling is commenced. End dumping will be permitted only on written consent of the engineer, and such written permission shall definitely limit the extent to which embankment material may be placed in this manner. Where the ground is swampy and will not support hauling equipment, the lower part of the fill up to a height not greater than necessary to support the hauling equipment, may be made by end dumping. The remainder of such fills shall then be constructed in layers and compacted as required.

19.6 Compaction. The ground surface upon which the embankment is to be placed shall be plowed or scarified for a depth of at least six inches and then compacted as required for each layer of embankment. This will not be required if the ground is rocky or if, in the opinion of the engineer, rolling and watering will result in no material additional compaction.

Each layer of embankment before starting the next, shall be uniformly compacted by heavy hauling equipment, power rollers, tamping rollers, or pneumatic tired rollers.

The relative compaction of earthy material composing each layer of embankment shall be not less than 90 percent, as determined by the compaction tests specified in Article 6.4 (d), of these specifications.

Embankment material which is not sufficiently moist to compact shall be sprinkled with water as directed by the

engineer, either during excavation or when being placed in embankment. If the embankment material is rock, sufficient water shall be applied to flush the fine particles into the interstices of the rock.

The top six inches of the completed subgrade, in cuts, shall be compacted to the same density as required for each layer of embankment.

Rolling shall be performed with equipment specified in Section 28.

19.7 Maintenance. Embankments shall be maintained true to grade and cross section until the completion of the contract, and the contractor shall be responsible for the stability of all embankments and shall replace any portions which, in the opinion of the engineer, have become displaced due to his carelessness or negligence.

19.8 Method of Measurement and Basis of Payment. Embankments shall not be measured or paid for directly, but shall be considered as incidental to the various items of earthwork except as follows:

(a) Sod or soft areas removed from the foundation shall be measured and paid for as roadway excavation.

(b) Trenches dug along the toe of fill slopes and steps more than four feet wide cut into sidehills as directed by the engineer shall be measured and paid for as roadway excavation. No direct payment shall be made for plowing embankment areas as specified nor for benching when the required width of bench is not more than four feet.

(c) Water used for compaction in accordance with the engineer's instructions shall be paid for as specified in Section 27.

(d) Rolling shall be paid for as specified in Section 28.

SECTION 20—STRUCTURE EXCAVATION

20.1 Description. This item shall consist of all excavation for foundations for culverts, culvert headwalls, bridges, and all other structures, and the disposal of all material obtained from such excavation. Except as provided under Section 21, it shall include backfilling to the level of the original ground. It shall include all necessary bailing, draining, sheeting, and the construction of cribs or cofferdams, if found necessary, and shall also include the subsequent removal of cofferdams and cribs when required.

20.2 Classification. No classification of structure excavation shall be made on the basis of materials or conditions encountered. Classification of excavation, if any, shall be made on the basis of the material removed between certain elevations, and such classification as shown on the plans or special provisions shall not be changed regardless of the material encountered.

20.3 Notification of Start of Work. The contractor shall notify the engineer a sufficient time in advance of the beginning of excavation for structures, so that cross sectional elevations and measurements may be taken of the existing ground and structure. Any material removed or excavated before these measurements have been taken shall not be paid for. The natural ground adjacent to the structure shall not be disturbed without permission of the engineer.

20.4 Depth of Excavation. Foundation pits shall be excavated according to the outlines of the footings, as shown on the plans, and shall be of sufficient size to permit the placing of the full width and length of the footings shown. The elevations of the bottoms of footings, as shown on the plans, shall be considered as approximate only and the engineer may order, in writing, such changes in dimensions or elevations of footings as may be necessary to secure a satisfactory foundation.

20.5 Disposal of Material. All excavated material, so far as suitable, shall be utilized as backfill or embankment. The surplus material, whether or not temporarily allowed

to be placed within the stream area, shall finally be disposed of in such manner as not to obstruct the stream or otherwise impair the efficiency or appearance of the structure. No excavated material shall be deposited at any time so as to endanger the partly finished structure.

20.6 Treatment of Foundation Material. Boulders, logs, or any other unforeseen obstacles encountered in excavation shall be removed. All rock or other hard foundation material shall be freed from all loose material, cleaned and cut to a firm surface, either level, stepped, or serrated, as directed by the engineer. All seams or crevices shall be cleaned out and grouted. All loose and disintegrated rock and thin strata shall be removed. When masonry is to rest on an excavated surface other than rock, special care shall be taken not to disturb the bottom of the excavation, and the final removal of the foundation material to grade shall not be made until just before the masonry is to be placed, except as provided in foundation fill, Section 22. Should the contractor remove foundation excavation below grade, he shall backfill to the required elevation at his own expense with concrete or with foundation fill, as directed by the engineer. Where foundation piles are used, the excavation of each pit shall be completed before the piles are driven. After the driving is completed, all loose and displaced material shall be removed, leaving a solid bed to receive the masonry.

20.7 Cofferdams. Suitable and practically watertight cofferdams shall be used wherever water - bearing strata are encountered above the elevation of the bottom of the excavation. Upon request, the contractor shall submit drawings showing his proposed method of cofferdam construction and other pertinent features not shown in detail on the plans. Such drawings shall be approved by the engineer before construction is started, but such approval shall not operate to relieve the contractor of any of his responsibility under the contract for the successful completion of the improvement.

Cofferdams or cribs for foundation construction shall, in general, be carried well below the bottom of the footings

and shall be well braced and as watertight as practicable. In general, the interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exterior, and to permit pumping outside of the forms. Cofferdams or cribs which are tilted or moved laterally during the process of sinking shall be righted or enlarged so as to provide the necessary clearance, and this shall be at the sole expense of the contractor.

Cofferdams shall be constructed so as to protect green concrete against damage from a sudden rising of the stream and to prevent damage to the foundation by erosion. No timber or bracing shall be left in cofferdams or cribs in such a way as to extend into the substructure masonry, without written permission from the engineer. When written permission is granted by the engineer, cofferdams, cribs, and sheeting may be cut off level with the footing.

Unless otherwise provided, cofferdams or cribs, with all sheeting and bracing, shall be removed by the contractor after the completion of the substructure. The removal shall be effected in such a manner as not to disturb or mar the finished masonry.

20.8 Foundation Seal. When conditions are encountered which, in the opinion of the engineer, render it impracticable to unwater the foundation before placing masonry, he may require the construction of a concrete foundation seal of such dimensions as may be necessary, and of such thickness as to resist any possible uplift. Concrete for such seal shall conform to all the requirements and specifications for concrete for structures. The foundation shall then be pumped out and the balance of the masonry placed in the dry. When weighted cribs are employed and the weight utilized to partially overcome the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage, such as dowels or keys, shall be provided to transfer the entire weight of the crib into the foundation seal. When a foundation seal is placed under water, the cofferdam shall be vented or ported at low water level as directed.

20.9 Pumping. Pumping from the interior of any foundation enclosure shall be done in such manner as to pre-

clude the possibility of any portion of the concrete materials being carried away. No pumping shall be permitted during the placing of concrete, or for a period of at least twenty-four hours thereafter, unless it be done from a suitable sump separated from the concrete work by a watertight wall. Pumping to unwater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

20.10 Inspection. After each excavation is completed, the contractor shall notify the engineer, and no masonry shall be placed until after the engineer has approved the depth of the excavation and the character of the foundation material.

20.11 Backfilling. After the structure has been completed, the areas around the foundation shall be filled with approved material as required in Section 21.

20.12 Method of Measurement. The quantity to be paid for shall be the yardage, measured in original position, of the material actually removed as hereinbefore prescribed, except that no yardage shall be included of excavation outside of a volume bounded by vertical surfaces 18 inches outside the neat footings and parallel thereto; and in the case of trenching for pipe culverts and pipe culvert extensions, no yardage shall be included of excavation outside of a volume bounded by vertical surfaces 12 inches from the sides of the pipe and parallel thereto, for pipes 30 inches or less in diameter, and 18 inches from the sides of the pipe and parallel thereto, for pipes 36 inches or over in diameter.

20.13 Basis of Payment. The yardage, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Structure Excavation," which price shall be full compensation for the excavating, backfilling, except as provided in Section 21, disposing of surplus materials, and for furnishing all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work; provided, that in the case of bridges when it is found necessary to carry footings more than three feet below the elevation shown on the plans, such work shall be paid for as extra work.

SECTION 21—BACKFILL

21.1 Description. This item shall consist of backfilling all bridges, box and pipe culverts, retaining walls, and other structures within the limits of the roadway except perforated or tile drain culverts. It does not include backfilling minor miscellaneous structures outside the limits of the roadway.

21.2 Materials. Materials for backfill shall conform to the requirements for imported borrow, selected material base, gravel base courses, or gravel surface courses.

21.3 Placing. No material shall be placed against the back of concrete abutments or concrete retaining walls until the masonry has been in place 21 days, except that this time may be reduced when laboratory tests indicate that the concrete has developed a strength of 2,500 pounds per square inch in compression.

Backfill over and around culverts, arches, and columns shall be brought up uniformly on all sides at approximately the same time and elevation.

Backfill shall be placed in horizontal layers not exceeding four inches in depth before compaction. Each layer shall be moistened, tamped, puddled, rolled, or otherwise compacted until the relative compaction is not less than 90 percent as determined by the compaction test specified in Section 6. If the designated backfill material is sandy or granulated material, the layer construction may be eliminated and compaction obtained by ponding or jetting. Ponding or jetting will not be permitted where the backfill material is such that it will soften when saturated, nor in the case of high abutments or retaining walls where ponding or jetting might develop hydrostatic pressure behind the walls.

21.4 Method of Measurement. When such an item is included in the proposal, the quantity to be paid for shall be the number of cubic yards of compacted material in place in the completed and accepted work, limited as follows:

(a) For that portion below the top limits of structure excavation, the volume shall be that measured for structure excavation less the volume of the structure therein.

(b) For that portion above the top limits of structure excavation, the volume to be measured shall not exceed that between planes extending from the top limits of structure excavation to the elevation required for backfill and a distance apart to provide the minimum berms specified above, except that the berm width measured for payment shall not exceed five feet unless otherwise indicated on the plans. The volume of the structure contained shall be deducted from the volume of backfill. Backfill above the top limits of structure excavation for headwalls for pipe culverts 36 inches or less in diameter shall not be measured or paid for directly.

21.5 Basis of Payment. When there is no such item in the proposal, backfill shall be considered as incidental to the installation of the structure and compensation shall be included in the contract prices for other items of the work.

When the proposal includes such an item, the quantity, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Backfill," which price shall be full compensation for furnishing all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work. Payment specified above shall not include compensation for roadway excavation, borrow, or imported borrow used for backfill. The quantities of these items required shall be paid for as specified for the particular material used, except that when there is no proposal item for borrow or imported borrow, the quantity required shall be measured and paid for as roadway excavation.

Water applied as directed by the engineer shall be measured and paid for as specified in Section 27.

Rolling as directed by the engineer shall be paid for in accordance with Section 28.

SECTION 22—FOUNDATION FILL

22.1 Description. This item shall consist of furnishing and placing rock or gravel backfill required to replace unsuitable foundation material below the foundation elevation for culverts, bridges, and all other structures.

22.2 Material. Foundation fill shall consist of suitably graded gravel or rock, as required by the engineer.

22.3 Construction Methods. After the unsuitable material has been excavated as required by the engineer, and piles driven if called for, the foundation fill shall be placed in uniform layers, as directed, to the foundation elevation, and each layer thoroughly compacted.

22.4 Method of Measurement. The yardage to be paid for shall be the yardage measured in its final position, of the material actually placed as foundation fill, except that no yardage shall be included outside of the vertical planes limiting the payment for structure excavation.

22.5 Basis of Payment. The yardage, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Foundation Fill," which price shall be full compensation for excavating, hauling, depositing, and compacting the materials placed, and for furnishing all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 23—DISPOSAL OF SURPLUS MATERIAL

23.1 Description. This item shall consist of the disposal of surplus or waste material of any classification of earth-work.

23.2 Construction Methods. All surplus excavation shall, if feasible, be used to widen embankments uniformly or to flatten slopes. If this is not feasible because of the character of the material, length of culverts in place, or for other reasons, the surplus material shall be disposed of as directed by the engineer at places and in such manner as to be inconspicuous from the highway and cause no interference with drainage. In no case shall material be deposited above the grade of the adjacent roadway unless directed in writing by the engineer.

23.3 Basis of Payment. This work shall not be paid for directly, but shall be considered as subsidiary work pertaining to roadway excavation or other class of earthwork.

Haul of surplus material in excess of the free haul specified shall be measured and paid for as specified under "Overhaul," Section 18.

SECTION 24—SHOULDERS

24.1 Description. This item shall consist of the construction of shoulders of approved materials, as indicated on the plans or in the special provisions, to the lines, grades, and cross sections shown on the plans or ordered by the engineer.

24.2 Materials. Where the shoulders are constructed wholly or in part of base course or surface course materials, such materials shall meet all of the requirements specified elsewhere in these specifications for the particular material used.

24.3 Construction Methods. Shoulders shall be constructed to the full width and to the level of the finished grade, as a part of the finished grade. Construction to final height and cross section shall proceed in the proper sequence with any base course or surface course to protect adequately the base course, surface course, or forms therefor. At all times the construction shall be so carried on that the finished grade, shoulders, and adjacent ditches will be effectively and completely drained.

When rolling of the finished grade is required, the shoulders likewise shall be rolled. Water shall be applied as directed by the engineer.

When base course or surface course materials are required on shoulders, such material shall be placed and finished in accordance with the specifications for base course or surface course applying.

24.4 Basis of Payment. Payment shall be made at the contract unit price or prices for base course or surface course materials used, measured as specified for the particular kinds of materials used. Payment shall also be made for all water acceptably used on the shoulders in accordance with engineer's instructions as specified in Section 27. Rolling shall be paid for as specified in Section 28. Payment for all required shaping, and finishing shall be considered as included in the contract unit price for other items. These payments shall be full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 25—RESHAPING ROADWAY

25.1 Description. This item shall consist of the preparation of the roadway where grading and construction substantially completed under previous contracts is to receive initial or additional surfacing.

Work shall consist of removing slides, trimming grade, surface, shoulders, roadway ditches, cut slopes, embankment slopes, parapets, or other portions of the roadway, to restore the required lines and grades.

25.2 Construction Methods. Work shall be performed by use of tractors, scarifiers, motor graders, rollers, and loading, hauling and watering equipment, supplemented by hand labor.

25.3 Basis of Payment. Work shall be paid for on a force account basis.

SECTION 26—ROADSIDE CLEANUP

26.1 Description. This item shall consist of cleaning and dressing roadside areas. It shall include the removal and disposal of rocks and boulders, logs, dead brush, rubbish, and other objectionable matter; obliteration of old roads to be abandoned; reshaping of old borrow or material pits; and selective clearing and trimming of trees and vegetation; all as indicated on the plans or as directed by the engineer. It shall not include any cleanup or other work made necessary by the contractor's operations as described in Article 4.10.

26.2 Construction Methods. Rocks and boulders designated for removal shall be removed and disposed of, either by depositing in bottoms of fills or by hauling and placing at points where, in the opinion of the engineer, they will not present an unsightly appearance. All logs, dead brush, rubbish, and other objectionable matter shall be burned or otherwise disposed of to the satisfaction of the engineer.

Old roads to be abandoned shall be obliterated by scarifying or other approved methods and old borrow or material pits shall be shaped, trimmed, and sloped. This work shall be performed in such manner that the roads or pits will blend with the adjacent landscape and so that the growth of vegetation will be promoted.

It is the intention herein to provide for a pleasing roadside, and all methods used shall be such as to protect and leave undamaged the existing ground surface and all vegetation. The use of scrapers of any kind or blade graders for the removal and disposal of rocks and boulders, logs, dead brush, rubbish, or other objectionable material will not be permitted unless specifically authorized by the engineer. All burning shall be done in such manner that the surrounding ground cover will not be damaged.

When required, the roadside shall be selectively cleared and grubbed. This shall consist of clearing the areas designated of unsatisfactory undergrowth, stumps, and trees as directed by the engineer. Desirable trees and undergrowth shall be protected. Dead and unsatisfactory limbs shall be

trimmed as directed. Debris from this operation shall be carefully burned or otherwise satisfactorily disposed of.

26.3 Method of Measurement and Basis of Payment. All roadside cleanup shall be paid for on a force account basis.

SECTION 27—WATERING

27.1 Description. This item shall include furnishing and applying water for compacting embankments, subgrade, surfacing, bases, and backfill, and for laying dust caused by grading operations and traffic.

It does not include water required for camp uses, mixing or curing Portland cement concrete, water incorporated at the plant in plantmixed products, or for other uses not specifically required to be paid for under these specifications.

27.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific reference to Part III is as follows:

Water.....Section 70

27.3 Construction Methods. Water shall be applied in amounts and at locations ordered by the engineer. It shall be sprinkled uniformly as directed by means of tank trucks equipped with suitable control apparatus, or by means of approved sprays attached to hose lines. Equipment used for watering shall have ample capacity to provide application of required amounts. When directed by the engineer, sprinkling shall be done at night or in the early morning hours when evaporation loss is at a minimum.

27.4 Method of Measurement. The quantity to be paid for shall be the number of 1,000 U. S. gallons actually applied as directed by the engineer. Measurement shall be made in tanks or tank trucks of predetermined capacity or by means of meters of a type approved by the engineer, which shall be furnished and installed by the contractor.

27.5 Basis of Payment. The quantity of water, measured as provided above, shall be paid for at the contract unit price per 1,000 gallons (M. gal.) for "Water," which price shall be full compensation for furnishing all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

The department reserves the right to increase, or to omit all or any part of the estimated amount of water to be used, and no additional compensation shall be allowed by reason of such increase or decrease.

SECTION 28—ROLLING

28.1 Description. This item shall consist of the compaction of embankments, subgrade, shoulders, gravel base courses, and gravel or crushed rock surface courses, in such manner and for such time as is ordered by the engineer, but does not include compaction of bituminous surface courses.

28.2 Equipment. Equipment used in compacting, including power units, in good mechanical condition shall comply with the following general requirements:

(a) Tandem Roller. The roller shall be self-propelled and weight not less than eight tons.

(b) Three-Wheel Roller. The roller shall be self-propelled and weigh not less than 10 tons.

(c) Tamping Roller. The roller shall have a minimum weight of 90 pounds per inch of width, and each individual tamper shall impose a pressure of not less than 100 pounds per square inch of its tamping face area. The width of the tamping roller shall be not less than eight feet, it shall be constructed in two or more sections in such a manner that each section is free to move and oscillate, and it shall be equipped with cleaner-teeth at the rear.

(d) Pneumatic-Tired Roller. The roller shall be equipped with pneumatic tires, mounted on two axles, staggered in such manner that the tires will come in contact with the entire surface over which the roller travels. The axles shall be mounted in a rigid frame of sufficient weight, or provided with a body or loading platform suitable for ballast, to effect a compression at each tire of not less than 225 pounds per inch of width of tire tread. The roller shall have an effective rolling width of 60 inches.

Motive power for roller equipment above described shall travel at not less than a rate of three miles per hour.

28.3 Method of Measurement and Basis of Payment. For each compaction unit, operation shall be paid for at the contract unit price per hour, operated as required by the engineer, which price shall be full compensation for all labor, materials, tools, supplies, equipment, motive power, operators, gasoline, oil, fuel, lubricants, and incidentals necessary for satisfactory operation.

The price bid for tamping roller shall cover a unit eight feet in width, either twin or single cylinder type. Should additional units be required they may be operated separately or in multiple, but in either case, each eight-foot unit in the combination shall be paid for as a single unit.

The department reserves the right to increase or decrease the estimated amount of rolling, and no compensation, other than the hourly rate, shall be allowed by reason of such increase or decrease.

SECTION 29—SELECTED MATERIAL BASE OR SURFACE COURSE

29.1 Description. This item shall consist of a base course or surface course composed of selected granular material constructed on the completed and accepted grade, in accordance with these specifications and in conformity with the lines, grades, and typical cross sections shown on the plans or ordered by the engineer.

29.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Selected material	Section 71

29.3 Placing. When the required compacted thickness is four inches or more, the material shall be placed in layers, none of which shall exceed four inches in depth before compacting. The material shall be distributed uniformly, either directly from the tail gates of the hauling vehicles while in motion or by approved spreader boxes, followed by such blade grader work as is necessary to remove all irregularities and to spread the material uniformly over the subgrade or previous layer. Each layer shall be finished to lines and grades before starting the succeeding layer.

If irregularities or segregations of materials occur in any layer during or after spreading, that layer shall be bladed into windrows, remixed until the segregations are eliminated, and then respread.

29.4 Watering. Water shall be applied just prior to and during all blading operations, in amounts directed by the engineer.

29.5 Compacting. Compaction shall be accomplished by rolling, hauling equipment, or other traffic distributed uniformly over the entire width of each layer, accompanied by frequent blading and watering as directed by the engineer. The sequence of operations shall be such that all sections of each layer shall be subjected to this traffic before being covered.

Rock particles larger than two inches in any dimension shall be removed and disposed of as directed by the engineer.

The finished course shall be smooth, true to lines, grades, and cross sections, and free from loose rocks or pebbles.

29.6 Maintenance. Waves, corrugations, and ruts shall not be allowed to form and the base or surface shall be bladed and dragged as often as is necessary to maintain it true to grade and cross section until the work is accepted or covered with another course.

29.7 Method of Measurement. The quantity to be paid for shall be the number of tons or the number of cubic yards, measured in the hauling vehicles at the point of loading, as indicated by the unit stated in the proposal form, conforming to all requirements, in the completed and accepted work.

29.8 Basis of Payment. The quantity of base or surfacing material, measured as provided above, shall be paid for at the contract unit price per ton or per cubic yard, for "Selected Material Base, or Surface," which price shall be full compensation for stripping of pit, crushing, screening, loading, hauling, and placing material on the roadway; for maintaining the base or surface; and for furnishing all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work, except watering and rolling.

The quantity of water acceptably applied shall be measured and paid for as provided in Section 27.

Rolling shall be paid for as specified in Section 28.

SECTION 30—GRAVEL BASE COURSES

30.1 Description. This item shall consist of a base course of pit run gravel, screened gravel, crushed gravel, or crushed stone placed upon the completed and accepted finished grade, or upon another base course, in accordance with these specifications and in conformity with the lines, grades, and typical sections shown on the plans or ordered by the engineer.

30.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Aggregate for Type 1 Gravel Base (3 grades—choice of size optional unless otherwise specified).....	Section 72
Aggregate for Type 2 Gravel Base (2 grades—size as specified).....	Section 72

30.3 Placing. In producing, handling, and placing base material care shall be taken to prevent segregation of the fine particles from the course. Base material shall be spread in one or more uniform layers of such depth that when compacted the course shall have the thickness shown on the plans. The thickness of each layer after compaction shall not exceed the following:

Type 1 Gravel Base.....	6 inches
Type 2 Gravel Base.....	4 inches

In placing pit run Type 1 base, larger sized particles of a minimum diameter equal to the compacted thickness of the layer being placed may be incorporated into that layer. Those pieces of oversize too large to be placed in the layer shall be bladed to the side of the roadway and disposed of in a manner satisfactory to the engineer.

Initial spreading of Type 1 gravel base shall be accomplished by the dumping of the material from the hauling vehicle directly from the tail gate or into approved spreading devices. Type 2 gravel base shall be spread by means of approved spreading devices.

After base course material has been spread, it shall be thoroughly blade-mixed to the full depth of the layer by

alternately blading the entire layer to the center and back to the edges of the road. It shall then be spread and finished to the required cross section by means of a modern motor patrol grader that will give the desired results as to uniformity and smoothness.

If it is necessary to add additional binder to the gravel base material after spreading, the necessary additional binder, as determined by the engineer, shall be distributed evenly over the loose gravel and thoroughly mixed by appropriate means.

30.4 Watering. Water shall be applied immediately prior to and during all blading operations, in amounts deemed necessary by the engineer, to moisten the material sufficiently to prevent segregation of the fine and coarse particles. Water shall be applied during the compaction and maintenance stages in sufficient amounts, as determined by the engineer, to assist in compaction and prevent raveling.

30.5 Compaction. Each layer of gravel base course shall be rolled with a power roller weighing at least eight tons. Rolling shall be parallel to the centerline of the road and shall begin at the outer edges, progressing gradually to the center. Wheels shall lap each preceding track by one half the width of such track and shall continue until all the surface has been rolled and the maximum feasible amount of compaction and bond have been obtained. Any irregularities or depressions that develop shall be corrected by loosening the material in these places and adding or removing material until the surface is smooth and uniform. After the rolling prescribed above has been completed, the top layer of the Type 2 gravel base shall be bladed with a motor patrol and again watered and rolled. Watering, and rolling, shall be performed alternately as required or directed to maintain a smooth, even, uniformly compacted base until any surface or treatment that may be provided for in the same contract is placed thereon, or until final acceptance.

Sections along curbs, near structures, and all other places not accessible to the compaction equipment shall be tamped thoroughly with mechanical tampers or with hand tampers that are sufficiently heavy to give good compaction.

30.6 Maintenance. Waves, corrugations and ruts shall not be allowed to form, and the base shall be bladed as often as necessary to maintain a true to grade cross section until the work is accepted or until it is covered with a succeeding course.

30.7 Method of Measurement. The quantity to be paid for shall be the number of tons or the number of cubic yards, measured in hauling vehicles at the point of loading, as indicated by the unit stated in the proposal, conforming to all requirements in the completed and accepted base.

30.8 Basis of Payment. The quantity of base material measured as provided above, shall be paid for at the contract unit price per ton or per cubic yard for "Type 1 Gravel Base," "Type 2 Gravel Base one inch," or "Type 2 Gravel Base one and one-half inch," as the case may be, which price shall be full compensation for stripping the pit, crushing, screening, loading, hauling, placing, and maintaining the base, and for furnishing all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work, except watering and rolling.

Water applied as directed shall be measured and paid for as specified in Section 27.

Rolling as directed by the engineer shall be paid for as specified in Section 28.

SECTION 31—GRAVEL SURFACE COURSE

31.1 Description. This item shall consist of a surface course of gravel, crushed gravel, or crushed stone, placed upon the completed and accepted subgrade or base course in accordance with these specifications and in conformity with the lines, grades, and typical sections shown on the plans or ordered by the engineer.

31.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Aggregate for roadmix and plant-mix bituminous surface.....	Section 73

31.3 Construction Methods. This surface course shall be built and finished as specified for Type 2 Gravel Base, Section 30.

31.4 Method of Measurement. The quantity to be paid for shall be the number of tons or the number of cubic yards, measured in the hauling vehicles at the point of loading, as indicated by the unit stated in the proposal form, conforming to all requirements in the completed and accepted surface.

31.5 Basis of Payment. The quantity of surfacing material, measured as provided above, shall be paid for at the contract unit price per ton or per cubic yard for "Gravel Surface," which price shall be full compensation for stripping of pit, crushing, screening, loading, hauling, placing, compacting, and maintaining the surface, and for furnishing all labor, tools, materials, supplies, equipment, and incidentals necessary to complete the work except watering and rolling.

Water applied as directed shall be measured and paid for as specified in Section 27.

Rolling shall be paid for as specified in Section 28.

SECTION 32—ROAD APPLICATION OF LIQUID ASPHALT

32.1 Description. This specification covers the equipment, methods, and method of measurement applying when liquid asphalt and asphalt emulsions are spread on the road as part of the construction of other items of these specifications.

32.2 Equipment. Distributors for applying liquid asphalt for prime coats, seal coats, or surface treatment shall be of approved pressure spraying types and shall be equipped with a full circulating spray bar and a positive shutoff that will instantaneously stop the flow of liquid asphalt without dripping; they shall be equipped with tachometer, volume and pressure gages, and shall have sufficient tractive power to maintain constant speed with varying road conditions. They shall be equipped with a built-in retort or other means of heating and maintaining the proper temperature on the contents of the tank. The engineer reserves the right to order the use of any equipment discontinued when in his opinion it fails to produce a satisfactory distribution of liquid asphalt in accordance with these specifications.

32.3 Weather Conditions. Applying liquid asphalt will not be permitted when the surface to be treated is wet or when weather conditions are unsuitable or when the atmospheric temperature is below 50° F. unless specifically ordered by the engineer.

32.4 Temperature of Application. Various grades of liquid asphalt shall be applied at not less than the minimum temperature specified below.

Grade of Liquid Asphalt	Minimum Distributor Application Temperature °F.
RC-0	100
RC-1	125
RC-2	150
RC-3	175
RC-4	200
RC-5	225
MC-0	100
MC-1	150
MC-2	175
MC-3	200
MC-4	225
MC-5	250
SC-0	100
SC-1	150
SC-2	200
SC-3	225
SC-4	250
SC-5	275
SC-6	300

32.5 Methods. Guard rails, bridges, culverts, posts, and all structures shall be adequately covered and protected both from direct spraying and from wind-blown spray. When such structures are spattered the contractor shall remove all traces of the liquid asphalt at his own expense. Effective methods shall be used to insure uniform application without overlapping at the beginning and end of each section. If so ordered by the engineer building paper shall be spread over the treated surface for a sufficient length back so that the sprayers are spreading properly when the uncovered surface is reached. Distribution shall be stopped promptly after uniform flow ceases, indicating that the tank is about empty. Uniform application will be required and the rate of application shall not vary from the rates specified by more than 10 percent. If any spots are missed,

liquid asphalt shall be applied to those spots by some means which will insure the application being made at the specified rate.

32.6 Method of Measurement. For purposes of payment the unit of measurement for liquid and paving asphalt shall be a ton.

Quantities of liquid asphalt wasted or disposed of in a manner not called for under the specifications, or remaining on hand after completion of the work will not be paid for.

The department will accept certified railroad weights, or certified weight factors satisfactory to the engineer, on all rail shipments of asphaltic materials.

If vehicles or containers other than railroad cars are used for transporting the asphaltic material the weight to be paid for shall be determined by weighing each vehicle or container on scales furnished by the contractor or on public scales, acceptable to the engineer, both before and after unloading, the difference in such weights being used as the basis for computing pay quantities.

When the specifications provide specifically that quantities of liquid asphalt to be paid for may be determined from volumetric measurements, the pay quantities shall be computed from the following tables:

CONVERSION TABLES—LIQUID ASPHALTS

Where measurement of liquid asphalts by volume is used, a gallon shall be construed to be a gallon in volume at a temperature of 60° F. The following tables shall be used for converting volume to weight. All types, SC, MC, and RC, of the same grade shall be considered to have equal weight per volume. For converting volume at any temperature to volume at 60° F. the Standard Abridged Volume Correction Tables for Petroleum Oils, A.S.T.M. D 206 shall be used.

TABLE FOR CONVERTING VOLUME TO WEIGHT

Type of Liquid Asphalt	Gals. Per Ton at 60° F.
Grade 0	257
Grade 1	251
Grade 2	248
Grade 3	245
Grade 4	243
Grade 5	241
Grade 6 (SC only)	239
Type Paving Asphalt	Gals. Per Ton at 60° F.
Pen. 40 to 100	235
Pen. 100 to 200	237
Pen. 200 to 300	239

**FACTORS FOR CONVERTING VOLUME OF LIQUID ASPHALT
FROM VOLUME AT ANY TEMPERATURE TO VOLUME
AT 60° F.****Group 0 (up to 14.9° API)**

This table applies to paving asphalts (all penetration grades) liquid asphalts, RC, MC, and SC grades, 2, 3, 4, and 5, and SC-6.

Coefficient of expansion at 60° F. = 0.00035.

Group 1 (15.0 to 34.9° API)

This table applies to liquid asphalts RC, MC, and SC grades 0 and 1.

Coefficient of expansion at 60° F. = 0.00040.

32.7 Conversion Factors for Asphalt Emulsions. Where measurement of emulsified asphalt by volume is used, a gallon shall be construed to be a gallon in volume at a temperature of 70° F. and 240 gallons of asphalt emulsion at a temperature of 70° F. shall be considered to be a ton. The following table shall be used to convert volume at any temperature to the volume at 70° F.:

CONVERSION TABLE FOR ASPHALTIC EMULSIONS

Coefficient of expansion at 70° F., 0.00025.

Temp. °F.	Conversion Factor	Temp. °F.	Conversion Factor	Temp. °F.	Conversion Factor
60	1.00250	90	.99500	121	.98725
61	1.00225	91	.99475	122	.98700
62	1.00200	92	.99450	123	.98675
63	1.00175	93	.99425	124	.98650
64	1.00150	94	.99400	125	.98625
65	1.00125	95	.99375	126	.98600
66	1.00100	96	.99350	127	.98575
67	1.00075	97	.99325	128	.98550
68	1.00050	98	.99300	129	.98525
69	1.00025	99	.99275	130	.98500
70	1.00000	100	.99250	131	.98475
71	.99975	101	.99225	132	.98450
72	.99950	102	.99200	133	.98425
73	.99925	103	.99175	134	.98400
74	.99900	104	.99150	135	.98375
75	.99875	105	.99125	136	.98350
76	.99850	106	.99100	137	.98325
77	.99825	107	.99075	138	.98300
78	.99800	108	.99050	139	.98275
79	.99775	109	.99025	140	.98250
80	.99750	110	.99000	141	.98225
81	.99725	111	.98975	142	.98200
82	.99700	112	.98950	143	.98175
83	.99675	113	.98925	144	.98150
84	.99650	114	.98900	145	.98125
85	.99625	115	.98875	146	.98100
86	.99600	116	.98850	147	.98075
87	.99575	117	.98825	148	.98050
88	.99550	118	.98800	149	.98025
89	.99525	119	.98775	150	.98000
		120	.98750		

SECTION 33—PRIME COAT

33.1 Description. This item shall consist of the application of liquid asphalt on a previously prepared base, road surface, or shoulder, and, if necessary, covering the application with a sand blotter.

33.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Sand blotter.....	Section 82
Liquid asphalt.....	Section 84

33.3 Construction Methods. Immediately before applying the prime coat, the surface shall be cleaned of all loose material and dirt by means of power brooms, supplemented by hand brooming if necessary. The surface to be primed shall be thoroughly bonded and compacted, true to grade and cross section, and free from ruts and inequalities.

The kind of liquid asphalt and the rate of application shall be as indicated on the plans or in the special provisions and shall be applied in accordance with the specifications for road application of liquid asphalt, Section 32.

After the liquid asphalt has penetrated the surface, the treated area shall be covered, where necessary, with sand blotter in sufficient quantity to absorb any excess liquid asphalt and prevent picking up by traffic.

33.4 Method of Measurement. Liquid asphalt shall be measured as specified in Section 32.

The quantity of sand blotter to be paid for shall be the number of tons or the number of cubic yards, as indicated by the unit stated in the proposal, measured in the hauling vehicles at the point of loading, conforming to all requirements in the completed and accepted work.

33.5 Basis of Payment. Liquid asphalt, measured as provided above, shall be paid for at the contract unit price per ton for the particular type of material required.

Sand blotter, measured as provided above, shall be paid for at the contract unit price per ton or per cubic yard for "Sand Blotter."

Payments specified above shall be full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 34—SEAL COAT

34.1 Description. This item shall consist of the application of liquid asphalt on a compacted and bonded bituminous surface and, if required, covering the application with a sand blotter.

34.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Sand blotter.....	Section 82
Liquid asphalt.....	Section 84

34.3 Construction Methods. Immediately before applying the liquid asphalt, the surface to be seal coated shall be thoroughly cleaned of all dirt and loose material by sweeping with power brooms supplemented by hand brooms if necessary.

The kind of liquid asphalt and the rate of application shall be as indicated on the plans or in the special provisions and shall be applied in accordance with the specifications for road application of liquid asphalt, Section 32.

After the liquid asphalt has penetrated the surface, the treated area shall be covered, where necessary, with sand blotter in sufficient quantity to absorb any excess liquid asphalt and prevent picking up by traffic.

34.4 Method of Measurement. Liquid asphalt shall be measured as specified in Section 32.

The quantity of sand blotter to be paid for shall be the number of tons or the number of cubic yards, measured in the hauling vehicles at the point of loading, as indicated by the unit stated in the proposal, conforming to all requirements in the completed and accepted work.

34.5 Basis of Payment. Liquid asphalt, measured as provided above, shall be paid for at the contract unit price per ton for the particular type of material required.

Sand blotter, measured as provided above, shall be paid for at the contract unit price per ton or per cubic yard for "Sand Blotter."

Payments specified above shall be full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 35—CLASS A-1 SURFACE TREATMENT

35.1 Description. This item shall consist of a surface covering of liquid asphalt and screenings applied on a previously compacted and bonded bituminous surface complying to cross section and profile shown on the plans.

35.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Screenings	Section 74
Liquid asphalt.....	Section 84

35.3 Construction Methods. Immediately before applying the surface treatment, the surface to be treated shall be thoroughly cleaned of all loose particles, earth, and other objectionable materials by sweeping with power brooms supplemented by hand brooms if necessary.

The kind of liquid asphalt, the rate of application, and the amount of screenings to be spread shall be as indicated on the plans or in the special provisions, and the liquid asphalt shall be applied in accordance with the specifications for road application of liquid asphalt, Section 32.

Screenings shall be spread at the rate specified by means of an approved mechanical spreader so designed that the material will be spread in a thin uniform sheet. In order to eliminate dust film, screenings shall be moistened with water before being applied, if so directed by the engineer. The rate of spread shall be adjustable and shall be changed as directed by the engineer. In spreading the screenings, the truck shall be operated backward so that the fresh liquid asphalt will be covered before the truck wheels come upon it.

Immediately following the spreading, the screenings shall be evenly distributed by hand brooms where necessary and then rolled with a power roller weighing not less than eight tons. Rolling shall commence at the outer edges and proceed toward the center of the pavement and shall be continued until the screenings are thoroughly set into the liquid asphalt.

Liquid asphalt shall not be applied in advance of spreading screenings over a greater distance than can be finished

before any setting or hardening of the liquid asphalt occurs. The distance over which the liquid asphalt is spread in advance of finishing shall be as determined by the engineer.

The finished surface shall be smooth and uniform in appearance, thoroughly bonded, and free from bare spots, ruts, humps, depressions, or other irregularities.

35.4 Method of Measurement. Liquid asphalt shall be measured as specified in Section 32.

The quantity of screenings for surface treatment to be paid for shall be the number of tons conforming to all requirements in the completed and accepted work.

35.5 Basis of Payment. Liquid asphalt, measured as provided above, shall be paid for at the contract unit price per ton for the particular type of material required.

Screenings, measured as provided above shall be paid for at the contract unit price per ton for "Screenings," which price shall include moistening if required.

Payments specified above shall be full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 36—CLASS A ARMOR COAT

36.1 Description. This item shall consist of the construction of a wearing course composed of three applications of bituminous material, each covered with mineral aggregate, placed upon a previously bituminized surface, or upon a thoroughly compacted base that has been given a prime coat, and which complies with the lines, grades, and cross section shown on the plans.

36.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Coarse aggregate.....	Section 74
Key rock.....	Section 74
Screenings	Section 74
Liquid asphalt.....	Section 84
Emulsified asphalt (pen. type) ..	Section 85

36.3 Equipment. Mineral aggregate shall be spread at the specified rate by means of an approved mechanical spreader so designed that the material will be spread in a uniform sheet. The rate of spread shall be readily adjustable.

Rollers shall be self-propelled tandem type, weighing not less than eight tons.

The blade graders used for leveling shall be of the self-propelled type, tightly articulated, having a wheel base of not less than 16 feet and a blade not less than 10 feet long. Stiff brooms with suitable devices for attaching to the blade of the grader or to the rollers shall be provided.

36.4 Construction Methods. When required on the plans or in the special provisions, a prime coat shall be applied in accordance with Section 33.

The sequence of the various operations and the approximate amount of materials shall be as shown in the following tables:

APPROXIMATE AMOUNT MATERIALS AND SEQUENCE OF OPERATIONS USING LIQUID ASPHALT

Operation	MATERIALS PER SQUARE YARD			
	Liquid Asphalt, Gallons	Coarse Aggregate, Pounds	Key Rock, Pounds	Screenings, Pounds
1st application.....	0.15			
1st spread.....		40		
Blade, broom, roll				
2d application.....	0.30			
2d spread.....			12	
Blade, broom, roll				
3d application.....	0.15			
3d spread.....				8
Blade, broom, roll				
Approx. total.....	0.60	40	12	8

APPROXIMATE AMOUNT MATERIALS AND SEQUENCE OF OPERATIONS USING EMULSIFIED ASPHALT

Operation	MATERIALS PER SQUARE YARD			
	Emulsified Asphalt, Gallons	Coarse Aggregate, Pounds	Key Rock, Pounds	Screenings, Pounds
1st application.....	0.10			
1st spread.....		36		
Blade, roll lightly				
2d application.....	0.35			
2d spread.....			16	
Blade, broom, roll				
3d application.....	0.25			
3d spread.....				8
Blade, broom, roll				
Approx. total.....	0.70	36	16	8

In hot dry weather, or when ordered by the engineer, aggregate shall be moistened before applying emulsified asphalt.

Bituminous material of the kind indicated on the plans or in the special provisions shall be applied in accordance with Section 32.

The first application of bituminous material shall be covered immediately with coarse aggregate which shall be bladed and broomed to a smooth, true, uniform surface.

It shall then be rolled until the aggregate is thoroughly keyed together and embedded in the asphalt. In spreading the aggregate the truck shall be operated backward so that the fresh bituminous material will be covered before the truck wheels come upon it.

Each succeeding spread of aggregate shall be made promptly after applying the bituminous material, and shall be bladed and broomed to a smooth, uniform, true surface, and rolled until thoroughly set into the voids and keyed together. Such brooming as is necessary to distribute the aggregate uniformly shall accompany the rolling. Additional aggregate shall be applied by hand during the rolling and brooming operations to cover any bare or inadequately covered places.

The finished surface shall be smooth, uniform in appearance, and thoroughly bonded, except for a slight excess of loose screenings on the surface. Maintenance of the surface until completion of the contract shall include occasional redistribution of loosened screenings over the surface by brooming and additional rolling.

36.5 Method of Measurement. Liquid asphalt shall be measured as specified in Section 32.

The quantity of aggregate for armor coat to be paid for shall be the number of tons of each of the classes used, conforming to all requirements in the completed and accepted work.

36.6 Basis of Payment. Liquid asphalt, measured as provided above, shall be paid for at the contract unit price per ton, for the particular type of material required.

Aggregate, measured as provided above, shall be paid for at the contract unit price per ton for "Coarse Aggregate," "Key Rock," or "Screenings," as the case may be.

The quantity of water acceptably applied shall be measured and paid for as provided in Section 27.

Prime coat, when required, shall be measured and paid for as specified in Section 33.

Payments specified above shall constitute full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 37—CLASS B-1 ROADMIX SURFACE

37.1 Description. This item shall consist of the construction of a surface course of dense graded aggregate and slow curing liquid asphalt, mixed in place on the roadbed and spread and compacted in accordance with these specifications and in conformity with the lines, grades, and cross sections shown on the plans or ordered by the engineer.

37.2 Materials. All material shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Aggregate for roadmix and plantmix	
bituminous surface.....	Section 73
Liquid asphalt (SC type).....	Section 84

37.3 Placing Aggregate. When all or part of the aggregate required for the construction of the roadmix surface is to be placed, the surface of the road shall be scarified lightly to a depth just sufficient to permit elimination of irregularities and reshaping true to grade and cross section. The required amount of aggregate shall then be placed and compacted in accordance with the specification for gravel surface course, Section 31. When the aggregate is to be treated with liquid asphalt immediately after being placed, the compaction requirement on the portion to be incorporated in the mix may be waived at the discretion of the engineer, provided that, in his opinion, there will be no segregation of materials nor loss of fines.

37.4 Preparation for Mixing. Prior to spreading the liquid asphalt, the roadway shall be bladed true to lines and grade. The surface shall then be scarified to a uniform depth sufficient to produce the required amount of loose material on an undisturbed base, and the loosened material shall be thoroughly mixed, pulverized, and dried. If necessary to eliminate irregularities in grading or excess moisture, the loosened material shall be bladed into windrows and turned until the mass is uniform and dry. It shall then be respread. The aggregate shall not contain more than one and one-half percent of moisture by weight when the liquid asphalt is applied.

37.5 Equipment. The equipment used by the contractor shall include scarifying, mixing, spreading, finishing, and compacting equipment, a self-powered bituminous material distributor and equipment for heating bituminous material. Blade graders for mixing shall be either self-powered or tractor drawn and shall have wheel bases of not less than fifteen feet. Crawler type tractors shall have street plates or flat treads. Discs, spike tooth, and spring tooth harrows shall be so designed that cutting into the subgrade can be avoided. Blade graders for laying, shaping, and finishing the mixture shall be of the self-propelled type, and shall have wheel bases of not less than sixteen feet. Rollers for compacting the surface shall be of the self-propelled tandem type weighing not less than eight tons each, or pneumatic rollers conforming to Section 28.

37.6 Applying Liquid Asphalt. The liquid asphalt shall be distributed uniformly in three applications, each of approximately one-third of the total required amount as determined by the engineer. It shall be applied uniformly at the temperature prescribed in these specifications for the particular material. The amount and kind or kinds of liquid asphalt shall be as shown on the plans or in the special provisions.

Immediately following each application, sufficient mixing shall be done with an assemblage of disc or other harrows or equivalent equipment to partially absorb the liquid asphalt and prevent formation of pools.

37.7 Mixing. After the final application of liquid asphalt and the harrowing specified above, the entire mass of material to be mixed shall be moved by heavy blade graders into a windrow, near the center of the road and then mixed by the assemblage of mixing units by blading the material from side to side of the road or by manipulations producing equivalent results until all particles are coated with liquid asphalt and the whole mass has a uniform color. During this operation the blades shall be set so as to cause a revolving motion of the mixture. Blading shall be accompanied by constant mixing with harrows. The mix shall be deemed complete when all free liquid asphalt has been scraped from the base, and the mixture is free

from lumps and spots with excess liquid asphalt. If the mixture is found to contain an excess of liquid asphalt, additional untreated surfacing material shall be loosened and incorporated into the mix, and if it is found to contain a deficiency of liquid asphalt, the necessary additional amount of liquid asphalt shall be applied in the same manner as the original applications. In either case the mixing shall be resumed and continued until the entire mass is completely mixed. Oversized rocks or stones appearing in the mix from any cause shall be removed when exposed, and shall be disposed of as directed by the engineer.

If rain occurs during the mixing operations, the material shall be windrowed and left undisturbed until it can be mixed and spread under dry conditions, except for such turning as may be necessary to reduce the moisture content of the mix to not more than one and one-half percent by weight.

Either traveling or stationary mixing plants or other equipment of proved performance may be used by the contractor in lieu of the methods specified above, provided results obtained are equal to those obtainable by the specified method and equipment. Approval of the use of other methods and equipment by the engineer shall not be construed to relieve the contractor of the responsibility for obtaining satisfactory results.

37.8 Finishing. After the mixture has been spread, the top half shall be bladed into a windrow on one side and then evenly respread over the entire surface. This operation shall be repeated, alternating the windrow from one side of the road to the other and to the center, and gradually decreasing the amount of material moved, until the entire surface has a uniform texture, is smooth, true to cross section and profile, and is uniformly compacted.

37.9 Compacting. Upon completion of the blading and as soon as the surface has set sufficiently to prevent shoving, the surface shall be rolled. Rolling shall commence at the outer edges and progress toward the center of the road until the entire surface has been covered. Rolling shall continue until the surface is of uniform texture and degree of compaction and is true to grade and cross section.

Pneumatic tired rollers may be used for compaction, but in case they are used, the final finishing shall be done with a tandem roller.

37.10 Refinishing. If any excess or deficiency of liquid asphalt develops during the compaction period or at any time prior to final acceptance, it shall be remedied by adding more aggregate or liquid asphalt as required, remixing, and refinishing.

If rain falls during the compaction period and penetrates into the surface to such an extent that the surface swells and cracks, the surface shall be scarified, bladed into windrows, and turned until it has been dried out. It shall then be respread and refinished.

37.11 Seal Coat. After the surface has been finished and under traffic for a period of time sufficiently long in the opinion of the engineer to have thoroughly compacted the entire surface a seal coat shall be applied in accordance with Section 34.

37.12 Method of Measurement. Liquid asphalt shall be measured as specified in Section 32.

Mixing shall be measured in miles along the center line of the roadway, and no extra allowance shall be made for widened sections and intersections except as provided below.

When separate payment for mixing intersections is provided as shown by an item in the proposal, the number of intersections mixed shall be measured as units.

37.13 Basis of Payment. Aggregate, when required, shall be measured and paid for as specified in Section 31.

Liquid asphalt used in the mix, and measured as provided above, shall be paid for at the contract unit price per ton, for the particular type of material applied.

Mixing, measured as provided above, shall be paid for at the contract unit price per mile for "Roadmix."

If the proposal contains a separate estimate of quantities, intersections mixed, measured as provided above, shall be paid for at the contract unit price each for "Roadmix Intersections." When the proposal does not include such an item, compensation for this work shall be considered as being included in the contract prices for other items of the work.

Seal coat shall be measured and paid for as specified in Section 34. Prime coat, if necessary, shall be measured and paid for as specified in Section 33.

Payments specified above shall constitute full compensation for all labor, material, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 38—CLASS C-1 ROADMIX SURFACE

38.1 Description. This item shall consist of the construction of a surface course of dense graded aggregate and medium curing or rapid curing liquid asphalt, mixed in place on the road and compacted, in accordance with these specifications and in conformity with the lines, grades, and cross sections shown on the plans or ordered by the engineer.

38.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Aggregate for roadmix and plantmix

bituminous surface.....Section 73

Liquid asphalts (MC or RC types).....Section 84

38.3 Construction Methods. All of the requirements of Articles 37.1 to 37.11, inclusive, shall apply with the following additions:

If, in the opinion of the engineer, after the mixing has been completed, the mixed material is not completely aerated, it shall be windrowed and allowed to stand for such period as the engineer may direct to secure complete aeration of the solvent. During this period the windrow shall be turned over completely at least twice a day.

38.4 Measurement and Payment. Measurement and payment shall be made in accordance with all the provisions of Articles 37.12 and 37.13.

SECTION 39—CLASS C-2 RETREAD SURFACE

39.1 Description. This item shall consist of a surface course composed of coarse aggregate, key rock, and screenings uniformly mixed, penetrated, and bound together with emulsified asphalt, or rapid curing liquid asphalt, and placed upon an approved base in accordance with these specifications and in conformity with the lines, grades, and cross sections shown on the plans. Two types are specified; the type applying shall be as shown on the plans or in the special provisions.

39.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Aggregate for retread.....	Section 74
Liquid asphalt (RC type).....	Section 84
Emulsified asphalt.....	Section 85

39.3 Equipment. Aggregate shall be spread by means of an approved mechanical spreader so designed that the material will be spread in a uniform sheet. The rate of spread shall be readily adjustable.

Blade graders for mixing and blading shall be of the self-propelled type with a wheel base of not less than 16 feet, shall have a blade not less than 10 feet long, and pneumatic tires. Stiff brooms with suitable devices for attaching to the blade of the grader shall be provided for the brooming. Mixing may be done with special mixers designed for this purpose, if, in the opinion of the engineer, results are as good as obtainable with blade graders.

Rollers shall be of the self-propelled tandem type weighing not less than eight tons.

39.4 Preparation of Base. When the base course is a water-bound type, it shall be given a prime coat in accordance with Section 33 of these specifications prior to starting the surface course.

Where an old bituminized or cement concrete surface course is to serve as the base, it shall be thoroughly cleaned by brooming to remove all dust and loose material, all soft asphaltic patches and joint material shall be removed,

and all holes, depressions, and other irregularities shall be patched, built up, or otherwise corrected as directed by the engineer.

39.5 Construction Methods. Mineral aggregate shall be thoroughly dry when cutback asphalt is applied. During hot, dry weather, coarse aggregate shall be sprinkled with water before applying emulsified asphalt. Bituminous material shall be applied in accordance with Section 32 of these specifications.

The sequence of the various operations and approximate amounts of material shall be as shown in the following tables:

ESTIMATED QUANTITIES—TYPE 1 RETREAD
(Compacted Thickness 1½ inches)

Operation	Cutback Asphalt, gallon	MATERIALS PER SQUARE YARD OF SURFACE				
		Asphalt, gal.— Mixing	Penetra- tion	Coarse Aggre- gate, lbs.	Key Rock lbs.	Screen- ings, lbs.
1st spread .....	.....	.....	.....	.....	120	
1st application.....	0.30	0.30				
Mix						
2d application.....	0.30	0.30				
Mix, shape, roll						
2d spread .....	.....	.....	.....	.....	20	
Broom, roll						
3d application.....	0.40	.....	0.50			
3d spread.....	.....	.....	.....	.....	.....	10
Broom, roll						
Open to traffic						
4th application.....	0.30	.....	0.40			
4th spread.....	.....	.....	.....	.....	.....	15
Broom, roll						
Approx. total	1.30	0.60	0.90	120	20	25

ESTIMATED QUANTITIES—TYPE 2 RETREAD
(Compacted Thickness 1½ inches)

Operation	Cutback Asphalt, gallon	MATERIALS PER SQUARE YARD OF SURFACE				
		Asphalt, gal.— Mixing	Penetra- tion	Coarse Aggre- gate, lbs.	Key Rock lbs.	Screen- ings, lbs.
1st spread.....	.....	.....	.....	.....	135	
1st application.....	0.35	0.35				
Mix						
2d application.....	0.30	0.40				
Mix, shape, roll						
2d spread.....	.....	.....	.....	.....	14	
Broom, roll						
3d application.....	0.10	.....	0.10			
Curing period						
Open to traffic						
4th application.....	0.20	.....	0.20			
4th spread.....	.....	.....	.....	.....	.....	15
Approx. total	0.95	0.75	0.30	135	14	15

Coarse aggregate shall be uniformly spread upon the base and bladed to a smooth surface and uniform cross section. Immediately following the first application of bituminous material, coarse aggregate and bituminous

material shall be mixed, either by blading from side to side of the road or by other suitable means. Mixing shall continue until all particles of the aggregate are covered. The material shall then be spread and given a second application of bituminous material before the first application has dried or set. Mixing, as specified above, shall be resumed immediately following the second application of bituminous material, and shall continue until all particles are coated and the mixture is uniform in appearance. The mixture shall then be bladed to a smooth surface, true to profile and cross section.

When emulsified asphalt is used for the binder and begins to coalesce and strip from the aggregate, mixing or other manipulation shall be discontinued between the beginning of the set and complete adherence to the rock.

During the mixing and spreading, care shall be used to prevent disturbing the base or incorporating shoulder material into the mix.

After the mixture has been spread and is in the proper condition of tackiness, it shall be rolled so as to cover the whole surface once. The roller wheels shall be kept well moistened to prevent picking up of the mixture. After rolling once, all irregularities shall be removed by planing with a blade grader, and adding premixed material where required. Spots that tend to ravel shall be removed and replaced with premixed material. The surface shall then again be rolled once over.

When the first application has set sufficiently so that it will not be indented by the wheels of the truck, key rock shall be spread in the required amount as shown by the above table. The amount shall be just sufficient to fill the voids in the coarse aggregate. Key rock shall be broomed until evenly distributed over the surface, and shall then be rolled until embedded into the voids of the coarse aggregate and the whole mass is thoroughly bonded and locked and all surface voids are filled. Rolling shall be accompanied by such brooming as is necessary to sweep the rock into the voids. Additional key rock shall be added by hand to any spots where there is a deficiency.

When the key rock has been rolled into the surface voids as specified above, the third application of bituminous

material shall be applied. When Type 1 retread is specified, the third application of bituminous material shall be covered immediately with the first spread of screenings. The screenings shall be broomed and rolled and additional screenings shall be spread where required, as specified above for key rock. Rolling shall be resumed at the proper periods during several days. When Type 2 retread is specified, the third application of bituminous material shall not be covered, and shall not be disturbed until dry and thoroughly cured. The road shall then be opened to traffic for a period not less than ten days. The surface shall then be swept clean of all dirt and loose material and a fourth application of bituminous material applied and covered immediately with an application of screenings. Brooming and rolling shall follow as specified above for other applications.

The finished surface shall be smooth, true to required cross section, and free from ruts, humps, depressions, or irregularities. When tested with a straightedge 10 feet long placed on the surface parallel to the center line, the surface shall at no point vary more than one-quarter inch from the lower edge of the straightedge. Wherever excessively rich overlapping of joints has occurred, the entire surface within such area shall be removed and reconstructed with rock and screenings, and treated with penetration type emulsion as directed by the engineer. All irregularities in the surface shall be patched with penetration type emulsion and screenings, the emulsion to be applied by means of a spray nozzle. Care shall be exercised in the application of the emulsion to insure that the total amount applied on the patches is not in excess of that specified in the table above.

Maintenance until completion of the contract shall include brooming to redistribute any loose screenings over the surface.

39.6 Method of Measurement. Liquid asphalt shall be measured as specified in Section 32.

The quantity of aggregate to be paid for shall be the number of tons of each of the classes used, conforming to all requirements in the completed and accepted work.

39.7 Basis of Payment. Scraping and cleaning of old

surfaces serving as a base shall not be paid for directly but shall be included in the contract prices for other items.

Prime coat when required shall be measured and paid for as specified in Section 33.

Liquid asphalt measured as provided above shall be paid for at the contract unit price per ton for the particular type of material required.

Aggregate, measured as provided above, shall be paid for at the contract unit price per ton for "Coarse Aggregate," "Key Rock," or "Screenings," as the case may be.

The quantity of water acceptably applied shall be measured and paid for as provided in Section 27.

Payments specified above shall constitute full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work, including patching, or building up of depressions, holes, or other irregularities.

SECTION 40—CLASS F-1 PLANTMIX SURFACE

40.1 Description. This item shall consist of a surface course of graded aggregate and medium curing or rapid curing liquid asphalt mixed in a central mixing plant, and placed on a compacted base course, in accordance with these specifications, and in conformity with the lines, grades, and cross sections shown on the plans.

40.2 Materials. The materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Aggregate for roadmix and plantmix

bituminous surface.....Section 73

Liquid asphalt (MC or RC types).....Section 84

40.3 Equipment. All mixing plants used by the contractor shall be designed and assembled so as to properly dry, heat, screen, and mix the materials.

The plant shall have screens for separating the aggregates, capable at normal speeds of separating all aggregates to the required sizes. At least two storage bins so proportioned as to insure adequate dry storage of the appropriate fractions of the aggregate shall be provided. Each bin shall be provided with an overflow pipe of such size and at such location that backing up of material into other compartments will be prevented.

The plant shall be equipped for accurately proportioning the two or more sizes of aggregate and asphalt by weight, using either dial scales or multiple beam scales of a type approved by the engineer. Scales shall have an accuracy of one-half percent for all loads and shall be sealed at the expense of the contractor as often as the engineer may deem necessary to assure accuracy.

The plant shall have a drier suitably designed to heat and dry the aggregate to specification requirements. The drier shall be capable of preparing aggregate to the full rated capacity of the paving plant. Suitable accurate thermometric equipment shall be furnished for ascertaining the temperature of the aggregate discharged from the drier and also of the liquid asphalt.

The mixer shall be of the pug mill type, of design and

capacity satisfactory to the engineer. If the engineer finds that there is difficulty in obtaining the specified mixing time, he may require that the mixer be provided with an approved, accurate time lock that will lock the discharge gate of the weigh box after all the aggregates have been placed in the mixer, and that will not release the gate until the specified time has elapsed.

Equipment for heating the liquid asphalt shall consist of a retort or of steam coils so designed that the steam will not be introduced into the liquid asphalt.

Volumetric proportioning and continuous mixing may be substituted for weight proportioning and batch mixing, provided the equipment has an established background of service satisfactory to the engineer. However, the same gradation control of aggregates and uniformity of mix as required for the batching plant must be met.

Equipment used in placing and finishing shall be in good mechanical condition and shall be satisfactory to the engineer. Motor graders shall be tightly articulated, shall be equipped with rubber tires, and shall have a wheel base of not less than 16 feet.

Rollers shall be self-propelled tandem type, weighing not less than eight tons and at least one of them shall be of the three-axle tandem type equipped with a third roll having substantially the same diameter as the main rolls mounted in front of the two main rolls. This roller shall be so constructed that the third roll can be rigidly held in place when lowered to the plane of the treads of the other two rolls.

40.4 Field Laboratory. The contractor shall provide a field laboratory as specified in Section 69.

40.5 Preparation of the Mix. Fine material or filler, if required to meet the specified grading, shall be blended with the aggregate before screening into the separate compartments.

Aggregate shall be screened into at least two fractions and conveyed into separate compartments ready for proportioning and mixing. Should a bin contain 15 percent or more of material which is undersize for that bin, the bin shall be drawn and the material rescreened. At the time of mixing, the aggregate shall contain not more than

one percent of moisture, and shall be introduced into the mix at a temperature suitable for efficient mixing.

The different sizes of aggregate shall be combined in uniform batches by weighing and conveying to the mixer the proportionate amounts of each size required to meet the specified grading. Exact proportions of each size shall be as determined by the engineer, to obtain the most suitable mix falling within the limits of the specified grading. The required amount of liquid asphalt of the type shown on the plans or in the special provisions, as fixed by the engineer, shall be measured by weight into each batch, and shall be introduced into the mixture at a temperature suitable for efficient mixing. The amount used shall be sufficient to coat properly all particles of the aggregate.

Mixing shall continue until a uniform mixture with all particles thoroughly coated with liquid asphalt is obtained, but not less than 30 seconds after the liquid asphalt is introduced.

40.6 Placing. Prior to placing the mix on the road, the primed base shall be cleaned of all loose and foreign material, and shall be acceptable to the engineer.

The material shall leave the plant at such temperature and shall be so protected during transportation that it will be spread at a temperature suitable for manipulation. Operations shall be so planned that there will be no hauling or other traffic over the loose material.

40.7 Spreading. Spreading will not be permitted when the surface to be treated is damp or when weather conditions are unsuitable or when the atmospheric temperature is below 50° F. unless specifically ordered by the engineer.

Placing and compacting of the mixture shall be done in long sections, preferably not less than one-half mile in length, and in layers not to exceed two and one-half inches in thickness when compacted. The mixture shall be spread uniformly with approved spreader boxes. After spreading, one-half of the material shall be bladed to one side of the road and the remaining material bladed smooth, allowed to aerate properly, and then rolled once over. The windrow shall then be moved to the side that has been rolled and the unrolled portion of the half thickness layer shall

be bladed smooth, allowed to aerate properly, and then rolled once over. The material in the windrow shall then be respread uniformly over the surface. The operation of windrowing and respreading shall be repeated, alternating the windrow from one side to the other and to the center, and gradually decreasing the amount of material moved, until the solvent is properly aerated and the entire surface has a uniform texture, is smooth, true to cross section and profile, and is uniformly compacted.

If the mixture, at any time after spreading on the roadbed, should show a moisture content of more than one and one-half percent, it shall be bladed and rebladed into windrows, and turned as many times as may be necessary to reduce the moisture content to one and one-half percent by weight of the dry aggregate.

Rolling on each layer shall begin after the blading has been completed and as soon as the surfacing has set sufficiently to prevent shoving under the roller. The rolling shall be longitudinal and shall begin at the outer edges, progressing inward until the entire surface has been covered. Rolling shall be continued intermittently, allowing time in between rolling periods for further setting of the surface, until the surface is dense, hard, free from loose aggregate and traffic marks. Blading shall be resumed during the rolling if necessary to maintain a true surface.

If any areas show an excess or deficiency of liquid asphalt during the compaction period or at any time prior to final acceptance, they shall be removed and replaced with suitable mixture.

The finished surface shall be smooth and true to grade and cross section and free from ruts, bumps, or other irregularities. The edges of the compacted surfacing, if necessary, shall be trimmed uniformly to the required lines and cross sections before the shoulders are finished and rolled.

40.8 Intersections. Intersecting roads and approaches shall be surfaced with plantmix surfacing as indicated on the plans or ordered by the engineer. If a plantmix surfacing is not required on such roads or approaches from the normal edge of the roadway surface to the right of way line, the portion between the surfacing and the right of

way line shall be given a prime coat in accordance with Section 33.

40.9 Surface Treatment. After the surface has been finished and under traffic for a period of time sufficiently long, in the opinion of the engineer, to have thoroughly compacted the entire surface, a surface treatment shall be applied in accordance with Section 35.

40.10 Method of Measurement. Liquid asphalt shall be measured as specified in Section 32.

The quantity of plantmix surfacing to be paid for shall be the number of tons, conforming to all requirements, in the completed and accepted work, less the weight of the liquid asphalt incorporated in the mix.

40.11 Basis of Payment. Liquid asphalt used in the mix, measured as provided above, shall be paid for at the contract unit price per ton for the particular type of material used.

The quantity of surfacing, measured as provided above, shall be paid for at the contract unit price per ton for "Class F-1 Plantmix Surface."

Prime coat applied to the intersections shall be measured and paid for as specified in Section 33.

Surface treatment shall be measured and paid for as specified in Section 35.

Payments specified above shall constitute full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 41—CLASS F-2 PLANTMIX SURFACE

41.1 Description. This item shall consist of a surface course of graded aggregate and slow curing liquid asphalt or asphalt cement mixed in a central mixing plant, and placed on a compacted base course, in accordance with these specifications, and in conformity with the lines, grades, and cross sections shown on the plans.

41.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Aggregate for roadmix and plantmix	
bituminous surface.....	Section 73
Liquid asphalt (SC type).....	Section 84
Asphalt cement.....	Section 86

41.3 Equipment. All mixing plants used by the contractor shall be designed and assembled so as to properly dry, heat, screen, and mix the materials.

The plant shall have screens for separating the aggregates, capable at normal speeds of separating all aggregates to the required sizes. At least two storage bins proportioned so as to insure adequate dry storage of the appropriate fractions of the aggregate shall be provided. Each bin shall be provided with an overflow pipe of such size and at such location that backing up of the material into other compartments will be prevented.

The plant shall be equipped for accurately proportioning the two or more sizes of aggregate and asphalt by weight, using either dial scales or multiple beam scales of a type approved by the engineer. Scales shall have an accuracy of one-half percent for all loads and shall be sealed at the expense of the contractor as often as the engineer may deem necessary to assure accuracy.

The plant shall have a drier suitably designed to heat and dry the aggregate to specification requirements. The drier shall be capable of preparing aggregate to the full rated capacity of the paving plant. Suitable accurate thermometric equipment shall be furnished for ascertaining the temperature of the aggregate discharged from the drier and also the liquid asphalt.

The mixer shall be of the pug mill type, of design and capacity suitable to the engineer. If the engineer finds that there is difficulty in obtaining the specified mixing time, he may require that the mixer be provided with an approved, accurate time lock that will lock the discharge gate of the weigh box after all the aggregates have been placed in the mixer, and that will not release the gate until the specified mixing time has elapsed.

Equipment for heating the liquid asphalt shall consist of a retort or steam coils so designed that the steam will not be introduced into the liquid asphalt.

Volumetric proportioning and continuous mixing may be substituted for weight proportioning and batch mixing, provided the equipment has an established background of service satisfactory to the engineer. However, the same gradation control of aggregates and uniformity of mix as required for the batching plant must be met.

Equipment used in placing and finishing shall be in good mechanical condition and shall be satisfactory to the engineer.

The paver shall be an approved, self-propelled type which will spread and strike off a width equal to not less than one traffic lane (12 feet) in such a manner that no supplemental shaping will be required. It shall be equipped with an agitator, preferably of the pug mill type, and shall spread the material evenly and with uniform density and strike it off true to the required cross section. Screeds shall not follow minor irregularities in the base, shall be readily adjustable, and shall be provided with gages for accurate control of depth of spread.

Rollers shall be of the self-propelled tandem type, weighing not less than eight tons and at least one of them shall be of the three-axle tandem type equipped with a third roll having substantially the same diameter as the main rolls mounted in front of the two main rolls. This roller shall be so constructed that the third roll can be rigidly held in place when lowered to the plane of the treads of the other two rolls.

41.4 Field Laboratory. The contractor shall provide a field laboratory as specified in Section 69.

41.5 Preparation of the Mix. Fine material or filler, if required to meet the specified grading, shall be blended with the aggregate before screening into the separate compartments.

Aggregate shall be screened into at least two fractions and conveyed into separate compartments ready for proportioning and mixing.

Should a bin contain 15 percent or more of material which is undersize for that bin, the bin shall be drawn and the material rescreened. At the time of mixing, the aggregate shall contain not more than one percent of moisture, and shall be introduced into the mix at a temperature suitable for efficient mixing.

The two or more sizes of aggregate shall be combined in uniform batches by weighing and conveying to the mixer the proportionate amounts of each size required to meet the specified grading. Exact proportions of each size shall be as determined by the engineer to obtain the most suitable mix falling within the limits of the specified grading. The required amount of liquid asphalt of the type shown on the plans or in the special provisions, as fixed by the engineer, shall be measured by weight into each batch, and shall be introduced into the mixture at a temperature between 250° and 325° F.

The amount used shall be sufficient to coat properly all particles of the aggregate.

Mixing shall continue until a uniform mixture with all particles thoroughly coated with liquid asphalt is obtained, but not less than 30 seconds after the liquid asphalt is introduced.

41.6 Placing. Prior to placing the mix on the road, the primed base shall be cleaned of all loose and foreign material, and shall be acceptable to the engineer.

The material shall leave the plant at such temperature and shall be so protected during transportation that it will be spread at a temperature of approximately 225° F. Operations shall be so planned that there will be no hauling or other traffic over the loose material.

Placing will not be permitted when the base is damp, or when weather conditions are unsuitable, or when the atmospheric temperature is below 50° F. unless specifically ordered by the engineer.

Where the compacted thickness of the course exceeds two and one-half inches, it shall be laid, spread, and compacted in two layers of equal thickness. When it is necessary to keep one lane open to traffic, the first lane spread shall be rolled and thoroughly compacted, except approximately six inches along the inside edge, before turning traffic over it and before starting the spreading of the second lane. The edge of the plantmix surface at the center line of the roadway shall be carefully protected from traffic by the erection of light timber barriers until the full width of the surface has been laid and compacted, and all other necessary precautions shall be taken to obtain a tight, smooth joint.

Rolling shall follow spreading in proper sequence and shall continue until the layer or course is smooth and no further compression is possible. It shall begin at the edges and progress toward the center until the entire surface has been covered. Areas not accessible to the rollers shall be compacted by hand tamping with iron tampers of a type satisfactory to the engineer.

The finished surface shall be smooth and true to grade and cross section and free from ruts, humps, or other irregularities. The edges of the compacted surfacing, if necessary, shall be trimmed uniformly to the required lines and cross sections before the shoulders are finished and rolled.

41.7 Intersections. Intersecting roads and approaches shall be surfaced with plantmix surfacing as indicated on the plans or ordered by the engineer. If a plantmix surfacing is not required on such roads or approaches from the normal edge of the roadway surface to the right of way line, the portion between the surfacing and the right of way line shall be given a prime coat in accordance with Section 33.

41.8 Surface Treatment. After the surface has been finished and under traffic for a period of time sufficiently long, in the opinion of the engineer, to have thoroughly compacted the entire surface, a surface treatment shall be applied in accordance with Section 35.

41.9 Method of Measurement. Liquid asphalt shall be measured as specified in Section 32.

The quantity of plantmix surfacing to be paid for shall

be the number of tons, conforming to all requirements, in the completed and accepted work, less the weight of the liquid asphalt incorporated in the mix.

41.10 Basis of Payment. Liquid asphalt used in the mix, measured as provided above, shall be paid for at the contract unit price per ton for the particular type of material used.

The quantity of surfacing, measured as provided above, shall be paid for at the contract unit price per ton for "Class F-2 Plantmix Surface."

Prime coat applied to intersections shall be measured and paid for as specified in Section 32.

Surface treatment shall be measured and paid for as specified in Section 35.

Payments specified above shall constitute full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 42—SIDE FORMS

42.1 Description. This item shall consist of furnishing and placing side forms for supporting the edges of Portland cement concrete, bituminous concrete, and when required by the plans, other pavements, and for supporting the spreading equipment required for these courses. It shall also include removing and disposing of the side forms when the specifications do not require that they be left in place for a permanent support for the edges of the surfacing.

42.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific reference to Part III is as follows :

Timber, Douglas fir, 1600#f
joint and plank.....Section 100

NOTE—Steel forms of a type approved by the engineer will be permitted when the specifications do not require that the forms be left in place.

42.3 General Requirements. Side forms shall be placed along both edges of each strip of the specified type of pavement except that where the edge butts against a curb, gutter, or a previously placed strip of surfacing, side forms will not be required.

Before placing side forms the earth foundation upon which they are to rest shall be excavated to the proper grade and shall be hard and compact. Side forms shall have full bearing upon the earth for their entire length.

Side forms shall be placed with exactness to the required grade and alignment of the edge of the finished pavement. They shall be so set and supported that during the entire operation of placing, tamping, finishing and rolling the pavement they will not, at any time deviate vertically more than one-eighth inch from the proper elevation.

All forms, whether timber or metal, shall be thoroughly cleaned and oiled before being used and shall be restored to their original condition each time they are reused. Any length of form which fails to fully meet all the requirements shall not be reused.

42.4 Timber Side Forms. Timber side forms shall be surfaced on both edges and one side. The ends of each piece shall be sawed square. The nominal thickness shall not be less than four inches, the depth not less than the full depth of the pavement edge, and the length not less than 16 feet. Timbers with rounded edges, ends or corners damaged, or with any other defects shall not be used.

Timber side forms shall rest upon two-inch by three-inch stakes, spaced not more than four feet apart and driven with their tops to the line and grade for the bottom of the side forms. These shall be of adequate length to support the forms rigidly, but in no case shall they be less than eight inches long.

The side forms shall be secured to side stakes, spaced not more than four feet apart and driven vertically at intermediate points between the supporting stakes in such a manner that their tops will be one inch below the top edge of the side form. These stakes shall not be less than three inches wide, one and one-half inches thick, and 18 inches long. The length shall be increased when the character of the soil is such that it will not give sufficient bearing to an 18-inch stake.

Side forms shall be spliced with a section of timber two feet long, two inches thick, and six inches wide, which shall be nailed lengthwise, lapping the joints.

Side forms which are to remain in place permanently shall be nailed to the new pavement with 50-penny nails at intervals of not more than five feet, driven into the side forms from the inside, preferably between courses, and allowed to project.

The top edge of timber side forms shall be temporarily faced with steel strips during the passing of the finishing machine. The steel strips shall not be less than five-eighths inch by two and one-half inches in cross section, and not less than eight feet in length. Sufficient strips shall be provided to keep the forms faced well ahead of paving operations and prevent delay to the work. The strips shall be firmly attached to the top edges of the forms.

42.5 Metal Side Forms. Metal side forms shall be straight, free from warp, of heavy section, and of sufficient rigidity, both in the form and in the interlocking

connection with the adjoining forms, to prevent springing under the weight of the subgrade and paving equipment, or the pressure of the pavement when placed. Their depth shall be equal to the specified depth of the edge of the pavement, and the width of base shall not be less than eight inches. Forms shall be of the full depth required in one piece. The maximum deviation of the top surface of any section shall not exceed one-eighth inch from a plane surface, nor shall the inside face vary more than one-quarter inch from a plane surface.

Forms and form joints shall be installed so that they will support the weight of a heavy finishing machine without settlement or lateral movement and if necessary to secure such rigidity and supporting power, each length of form shall be supported on at least two stakes. Such stakes shall be two inches by three inches in size and of adequate length to support the form rigidly but in no case shall the stakes be less than eight inches long. The stakes shall be driven so that their tops will conform to the line and grade for the bottom of the side forms.

Metal forms shall be staked firmly by means of steel stakes spaced not more than five feet apart and shall be so designed that stakes may be driven through the base of the form. "L" shaped forms shall be provided with three stake pockets per section for locking stakes in position. Should the forms be of enclosed trapezoidal section, the use of two stake pockets will be permitted, but the usual number of stakes through the base of the form will be required. Metal side forms shall be laid with an expansion gap of one-quarter inch between the ends.

42.6 Removing Forms. Forms which are to be removed shall be allowed to remain in place for at least one full day after the completion of the pavement, and, when necessary in the opinion of the engineer, for such additional time as the pavement edge may require support. They shall be removed in such manner as to avoid breaking or otherwise damaging the edge of the pavement.

42.7 Method of Measurement. When side forms are left in place, and such an item is included in the proposal, the quantities to be paid for shall be the number of linear feet of form in place in the completed and accepted work.

42.8 Basis of Payment. Unless such an item is included as specified below, the contract price for the particular type of pavement shall be considered as including payment for the side forms.

If the proposal contains a separate estimate of quantities for side forms to be left in place, this item, measured as provided above, shall be paid for at the contract unit price per linear foot for "Side Forms," which price shall be full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 43—CLASS 1 ASPHALT CONCRETE SURFACE

43.1 Description. This item shall consist of a surface of one or more courses, composed of a mixture of coarse aggregate, fine aggregate, mineral filler, and asphalt cement thoroughly mixed in the proper proportion and placed upon the approved subgrade or base in accordance with these specifications and in conformity with the lines, grades, and cross sections shown on the plans or ordered by the engineer.

43.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Screenings	Section 74
Coarse aggregate for asphalt concrete...	Section 75
Fine aggregate for asphalt concrete.....	Section 79
Mineral filler	Section 80
Liquid asphalt.....	Section 84
Asphalt cement	Section 86

43.3 Side Forms. Side forms shall conform to and be placed in accordance with the requirements of Section 42.

Unless otherwise specified, side forms shall be allowed to remain in place along the outside edges of the surfacing.

43.4 Subgrade. Subgrade shall be constructed as indicated on the plans or in the special provisions. Subgrade shall be dry before laying the asphalt concrete.

When asphalt concrete is placed on an old pavement, the pavement surface shall be prepared as indicated on the plans or in the special provisions.

43.5 Methods. The methods employed in performing the work and all the equipment, tools, and machinery used for handling the material and executing any part of the work, shall be subject to the approval of the engineer. All equipment necessary for the laying of pavement shall be on hand and approved before laying operations are begun by the contractor.

43.6 Plant and Equipment. The plant shall be of a type suitable for the work and shall be so assembled and maintained that it will at all times properly heat, screen, and

mix the materials. The plant shall conform to the following requirements:

(a) DRIER. The drier shall be of the rotating cylindrical type designed to heat and dry the aggregates to specification requirements. The drier shall be capable of preparing aggregates to the full rated capacity of the paving plant.

(b) SCREENS. All plant screens shall be designed, constructed, and operated so as to screen all aggregates to the specified sizes and proportions and shall have capacities when operated at normal speeds, slightly in excess of the maximum capacity of the mixer.

(c) BINS. The plant shall have hot storage bins of sufficient capacity to furnish the necessary amount of all aggregates at a rate equal to the maximum rated capacity of the plant with no periods of undue waiting for materials.

Bins shall be divided into at least three compartments so proportioned as to insure separate and adequate storage of appropriate fractions of the aggregate. Each compartment shall be provided with an overflow pipe of such size and at such location as to prevent any backing up of material into other bins. Adequate dry storage shall be provided for mineral filler and provision made for proportioning the filler for each batch of mixture, if required.

(d) WEIGH BOXES. The plant shall have a weigh box capable of holding the maximum amount of aggregate for one batch. The weigh box shall be supported on fulcrums and knife edges so constructed that they will not be easily thrown out of alignment or adjustment. Edges, ends, and sides of weigh boxes must be free from contact with any supporting rods or columns or other equipment that will in any way affect the proper functioning of the weigh box. Discharge gates of the weigh box shall be so constructed that the aggregates will not be segregated when dumped into the mixer.

(e) Scales for the weigh box may be either of the multiple beam or springless dial type and shall be of a standard make and design, sensitive to one half of one percent of the maximum load that may be required. When of the beam type, there shall be a separate beam for each size of aggregate and a tare beam for balancing the weigh box. A tell-tale indicator shall be provided that will start to function when

the load being applied is within one hundred pounds of that desired. Beam scales shall be balanced on knife edges and fulcrums and shall be so constructed that they cannot be easily thrown out of alignment or adjustment. Dial scales shall be of a standard make and of such size that the numerals on the dial can be read at a distance of not less than 25 feet.

Scales for weighing of asphalt cement shall conform to the specifications for the scales for aggregate except that beam scales shall be equipped with tare beams and full capacity beams. The value of the minimum graduations shall not be greater than two pounds. Dial scales for weighing asphalt cement shall have a capacity of not more than twice the weight of the material to be weighed and shall read to the nearest pound. All scales shall be sealed at the expense of the contractor as often as the engineer may deem necessary to assure accuracy.

(f) ASPHALT WEIGH BUCKET. The asphalt weigh bucket shall be steam jacketed and shall have a capacity equal to 12 percent of the maximum capacity of the mixer. It shall be supported on fulcrums and knife edges in the same manner as the weigh box.

(g) THERMOMETRIC EQUIPMENT. An armored thermometer reading from 200° to 450° F. shall be fixed in the asphalt feed line at a suitable location near the discharge valve at the mixer. The plant shall also be equipped with an approved dial scale mercury actuated thermometer, an electric pyrometer, or other thermometric instruments so placed as to register automatically or indicate the temperature of the heated aggregate being discharged from the drier.

(h) MIXER. The plant shall include a batch mixer of an approved twin pug mill type, steam jacketed, equipped with a sufficient number of paddles or blades set in proper order to produce properly mixed batches of any material required under these specifications. When the engineer finds that there is difficulty in obtaining the specified mixing time, he may require that the mixer be provided with an approved, accurate time lock that will lock the discharge gates of the weigh box after all the aggregates have been placed in the mixer, and that will not release the gate until the specified time has elapsed.

(i) DUST COLLECTOR. All plants shall be equipped with an approved type of dust collector, with provisions for either wasting the dust collected or returning it uniformly to the mixture, as the engineer directs.

(j) EQUIPMENT FOR PREPARATION OF ASPHALT. Tanks for storage of asphalt shall be capable of heating the material effectively and positively. Heating shall be accomplished by steam coils, electricity, or other means whereby no flame comes in contact with the tank.

(k) AGGREGATE FEEDER FOR PLANT. The plant shall be provided with an accurate mechanical means for uniformly feeding the mineral aggregate into the drier so that a uniform production and a uniform temperature may be secured.

(l) Volumetric proportioning and continuous mixing may be substituted for weight proportioning and batch mixing provided the equipment has an established background of service satisfactory to the engineer. However, the same gradation control of aggregates and uniformity of mix as required for the batching plant must be met.

(m) Special requirements for continuous mixing plants. The plant shall include a means for accurately proportioning each bin size of aggregate either by weighing or by volumetric measurement.

When gradation control is by volume, the unit shall include a feeder mounted under the bins. Each bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring materials drawn from each bin. The orifice shall be rectangular, of dimensions about eight inches by nine inches with one dimension adjustable by positive mechanical means provided with a lock. Indicators shall be provided on each gate to show the gate opening in inches. Mineral filler, if specified, shall be proportioned separately from a small hopper mounted directly over the mixer.

The plant shall include a means for calibration of gate openings by means of weight test samples. The materials fed out of the bins through individual orifices shall be by-passed to a suitable test box, each bin material confined in a separate box section. The plant shall be equipped to handle conveniently such test samples weighing up to 800 pounds and to weigh them on accurate scales.

Satisfactory means shall be provided to afford positive

interlocking control between the flow of aggregate from the bins and the flow of asphalt from the meter or other proportioning source. This control shall be accomplished by interlocking mechanical means or any positive method under the control of the engineer.

The plant shall include a continuous mixer of an approved twin pug mill type capable of producing a uniform mixture within the job mix tolerance fixed by the contract. The paddles shall be of a type adjustable for angular positions on the shafts and reversible to retard the flow of the mix. The mixer shall carry a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on permanent gages and also giving the rate of feed of aggregate per minute, at plant operating speed.

Unless otherwise required, determinations of mixing time shall be by weight method under the following formula, the weights to be determined for the job by tests made by the engineer.

$$\text{Mixing time in seconds} = \frac{\text{Pug mill dead capacity in pounds}}{\text{Pug mill output in pounds per second}}$$

(n) Spreader boxes or other approved equipment shall be provided to distribute the asphalt concrete between the side forms. The distributing devices shall be arranged to provide for breaking up any compressed masses as they leave the truck, or auxiliary equipment may be provided for this purpose.

The paving machine shall be an approved self-propelled spreading, raking, and finishing machine, the screeds of which shall be supported on the side forms. It shall be provided with front and rear screeds and shall be equipped with a raking unit which extends the full width of the pavement. The screeds may be equipped with either vertically curved blades or flat blades. The paving machine shall be adequately powered and so weighted that the driving wheels will not slip when propelling the machine under load.

(o) ROLLERS. Rollers shall be self-propelled, in good mechanical condition, smooth running, and shall start and stop without jerking. One roller shall be either a ten ton three wheel roller with a compression on the rear wheels of not less than 325 pounds per linear inch of the tire width or a ten ton three axle tandem type; the remainder of the

rollers shall be eight ton tandem type rollers. The number of rollers used shall not be less than the number specified in the following table, except that if the three axle tandem type is used the number of rollers may be reduced by one.

Tons Laid Per Hour	Rollers Required
Less than 75	3
75 to 125	4
125 to 175	5
175 to 225	6

43.7 Proportioning the Mix. Coarse and fine aggregate and mineral filler shall be combined in proportions, as directed by the engineer, to produce a dense, well-graded mixture meeting the following size requirements:

Laboratory Sieve, Square Openings	PERCENTAGE BY WEIGHT PASSING SIEVE		
	Bottom Course	Leveling Course	Top Course
2 inch	95-100		
1 inch	65-80	95-100	95-100
$\frac{1}{2}$ inch	44-58	58-70	60-80
$\frac{1}{4}$ inch	30-40	28-54	40-55
No. 10	20-30	25-38	28-38
No. 40	13-20	15-25	20-27
No. 80	6-13	8-16	13-20
No. 200	1-4	2-6	5-11

Asphalt cement of the penetration grade shown on the plans or in the special provisions shall be added in the exact percentages as determined by the engineer.

MIXING. Coarse and fine aggregates shall be heated to a temperature of from 275° to 375° F. and thoroughly dried. The temperature of the coarse and fine aggregates shall not vary from each other by more than 30° F.

Mineral filler shall be added to each batch when necessary and shall be introduced separately into the mixer through the weigh box or as near the center of the mixer as possible.

The hot aggregates and the cold mineral filler, if necessary, properly proportioned by weight shall be thoroughly mixed in a pug mill mixer. Asphalt cement heated sufficiently to be readily mixed with mineral aggregate, but

not in excess of 400° F. shall be added during the mixing. Mixing shall then continue until a homogeneous mixture of unchanging appearance is produced. The time of mixing shall not be less than 45 seconds from the time all ingredients are in the mixer, except that for the base and leveling courses the time may be reduced, with the approval of the engineer, provided that the sizes of aggregate are uniformly distributed and all particles are thoroughly coated with asphalt.

43.8 Placing. The mixture shall leave the plant at such temperature and shall be so protected during transportation that it will be spread at a temperature of between 250° and 320° F.

Spreading will not be permitted when the base is damp or when weather conditions are unsuitable, or when the atmospheric temperature is below 50° F. unless specifically ordered by the engineer.

The hauling trucks shall be provided with spreader boxes or other suitable equipment for distributing the load at an even thickness throughout the entire length which a truck load should cover. After being distributed between the side forms, the mixture shall be spread by means of a self-propelled, spreading, raking, and finishing machine. The machine shall spread the mixture, rake it into longitudinal furrows and again strike it off so that it is smooth and true to cross section, free from all hollows and inequalities, and of a uniform density throughout. The spacing of the rake teeth and their depth of penetration into the mixture shall be under the control of the engineer.

If during the process of raking and spreading any yielding of the side forms occurs, they shall be reinforced by additional stakes and any other means necessary until they will support the weight of the machine without yielding.

Immediately after the surface course has been spread, shoulder material shall be placed against the side forms in such manner as to facilitate cross rolling.

Where the compacted thickness of any course exceeds four inches, it shall be laid in two or more compressions of approximately equal thickness, none of which shall exceed four inches.

When asphalt concrete is laid over an old pavement having excessive crown, irregularities, or insufficient super-elevation, and the required thickness of the course at any place exceeds four inches, an asphalt concrete course of the appropriate kind shall be laid to fill the low places and permit the succeeding course or compression to be laid in a uniform thickness.

Bottom and leveling courses shall not be laid for a distance exceeding one mile in advance of the succeeding course. The surface of each course shall be clean and free from foreign matter when the succeeding course is placed. Any surface which has become dirty shall be cleaned and, if ordered by the engineer, the surface shall be painted with a light coat of asphalt cement cut back with naphtha.

Placing of all courses shall be as nearly continuous as possible. No asphalt concrete surface course shall be spread which cannot be finished within daylight hours of the same day it is laid. In all cases where a joint is unavoidable, provisions shall be made for the proper bond for the full depth of the course. When the laying of the course is resumed, such joints shall be formed by cutting back the previously laid mixture and exposing a vertical face for the full depth of the course. The exposed face shall then be painted with a thin coat of asphalt cement cut back with naphtha and the fresh mixture raked against the joint. Longitudinal joints between paving strips shall be painted in the same manner.

43.9 Rolling. After each course of asphalt concrete has been uniformly spread as above specified, it shall be thoroughly rolled. Rolling shall continue on the bottom and leveling courses until the compressed material has a relative specific gravity of not less than 90 percent of the specific gravity of the combined aggregates and asphalt, and on the top course until it has a relative specific gravity of not less than 92 percent. Places inaccessible to the roller shall be tamped with hot iron tampers. All initial rolling or tamping shall be done with the temperature of the mixture such that the sum of the air temperature plus the temperature of the mixture is between 300° and 325° F. The first cross rolling shall be done with the temperature

of the mixture between 125° and 135° F. The final rolling shall be done with the temperature of the mixture at approximately 100° F.

The surface of the pavement shall be smooth and even with rock uniformly distributed, true to grade and cross section and free from elevations or depressions. When a straightedge ten feet long is laid on the finished surface parallel with the line of the highway, the surface shall in no place vary from the lower edge of the straightedge by more than one-eighth inch.

No traffic shall be allowed on the pavement until it is thoroughly cooled and set, except such traffic as may be necessary for construction purposes.

43.10 Samples. When called upon, the contractor shall furnish for tests, free of charge, undisturbed samples cut from any course or from the completed pavement. These samples shall be furnished in boxes of sufficient rigidity to insure against breaking of the asphalt concrete samples in transit.

43.11 Finish Coat. When required by the special provisions or directed by the engineer a surface treatment shall be applied as provided in Section 35.

43.12 Method of Measurement. The quantity of asphalt concrete to be paid for shall be the number of tons of two thousand pounds, conforming to all requirements in the completed and accepted work, less the weight of the asphalt cement incorporated in the mix.

The quantity of asphalt cement to be paid for shall be the number of tons of two thousand pounds conforming to all requirements in the completed and accepted work.

43.13 Basis of Payment. The quantity of asphalt concrete, measured as provided above, shall be paid for at the contract unit price per ton for "Asphalt Concrete Bottom Course," "Asphalt Concrete Leveling Course," or "Asphalt Concrete Top Course," as the case may be.

The quantity of asphalt cement measured as provided above shall be paid for at the contract unit price per ton for "Asphalt Cement."

Liquid asphalt and screenings for finish coat shall be measured and paid for as specified in Section 35.

Payments specified above shall constitute full compensation for furnishing, placing, and compacting the surface, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 44—BRIDGES, CULVERTS, AND RETAINING WALLS

44.1 Description. Bridges, culverts, culvert headwalls, and retaining walls shall be built as indicated on the plans and shall conform to the lines, grades, dimensions, and design shown, and in accordance with the specifications for the various items which constitute the complete structure.

44.2 Materials. All materials shall conform to the requirements prescribed for the several items which constitute each structure.

44.3 Construction Methods. The methods of construction shall conform to the following requirements:

REMOVAL OF EXISTING STRUCTURES. Where the removal and satisfactory disposal of existing structures are required, the work shall be performed as specified under removing structures and obstructions, Section 12.

EXCAVATION. Excavation for foundations and substructures shall be performed as specified under structure excavation, Section 20. Unless otherwise specified, foundations shall be constructed in open excavation and the foundation openings shall be shored, braced, or protected by cofferdams.

PRESERVATION OF CHANNEL. Unless otherwise specified, no excavation shall be made outside of caissons, cribs, cofferdams, steel piling, or sheeting, and the natural stream bed adjacent to the structure shall not be disturbed. Any excavation made at the site of the structure before caissons, cribs, or cofferdams are sunk shall be backfilled to the original ground surface or stream bed with satisfactory material at the contractor's expense. All excavated material and debris occurring in stream channels shall be removed to the level of the original ground line, and the whole site of operations cleaned up in a workmanlike manner.

PILING. Piling, when required or specified, shall be furnished and placed as specified under piling, Section 49.

PLACING CONCRETE. The concrete shall be placed and finished as specified under concrete structures, Section 45. Unless otherwise specified, all foundation excavation shall be pumped dry and concrete deposited in the open. Necessary reinforcing shall be placed as specified under reinforcing steel, Section 46.

MASONRY. Masonry, when required, shall be placed as specified under dry rubble masonry, Section 50, or mortar rubble masonry, Section 51, according to the type specified.

STRUCTURAL STEEL. Structural steel, including expansion rollers, rockers, and plates, when specified, shall be furnished and placed as specified under structural steel, Section 47.

TIMBER. Timber, when specified, shall be placed as specified under timber structures, Section 48.

PIPES FOR CULVERTS. Pipes for culverts, when required, shall be of the type specified and shall be installed as specified under pipe culverts, Section 52.

SURFACING. When surfacing is included in the contract, a surface of the required kind shall be placed in accordance with the specifications for the type specified.

44.4 Design. Design of bridges and incidental structures shall conform to standard of design as set forth in the Standard Specifications for Highway Bridges of the A. A. S. H. O.

44.5 Method of Measurement. The quantities of the various items which constitute the completed and accepted structure shall be measured for payment accordnig to the plans and specifications for the several pay items and in terms of the prescribed units provided for such items. Only accepted work shall be included, and the dimensions used shall be those shown on the plans or ordered by the engineer.

44.6 Basis of Payment. The quantities, measured as provided above, shall be paid for at the contract unit prices for the several pay items constituting the structure and listed in the proposal, which prices shall be full payment for furnishing, hauling, and placing all materials, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work as specified herein.

SECTION 45—CONCRETE STRUCTURES

45.1 Description. This item shall consist of furnishing and placing Portland cement concrete in bridges, culverts, headwalls, retaining walls, and all other types of concrete structures. The concrete shall be composed of Portland cement, fine aggregate, coarse aggregate, and water, proportioned and mixed as specified herein. The masonry shall be of the class and shall conform to the shapes, dimensions, and designs shown on the plans or ordered in writing by the engineer.

45.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Coarse aggregate for Portland cement concrete.....	Section 76
Fine aggregate for Portland cement concrete.....	Section 81
Portland cement	Section 89
Asphalt for waterproofing.....	Section 88
Sheet copper.....	Section 91
Premolded expansion joint filler.....	Section 105

Admixtures to prevent segregation and improve the workability of the concrete may be permitted, provided the material proposed for admixing shall first be approved by the engineer, and the proportions of the admixture to be used shall be fixed by him. No admixture shall be used without written permission from the engineer, or unless specifically provided in the plans or specifications. Admixtures shall not be used to replace cement.

45.3 Classification. Concrete shall be of four classes: Class A, Class B, Class C, and Class D. Each class of concrete shall be used in that part of the structure in which it is called for on the plans, or where directed by the engineer. The following requirements shall govern unless otherwise shown on the plans:

Class A concrete shall be used for reinforced substructures, retaining walls, and parts of superstructures.

Class B concrete shall be used for massive substructures and gravity walls with little or no reinforcing.

Class C concrete shall be used for very massive unreinforced sections.

Class D concrete shall be used for superstructures and in parts of substructures.

The following sizes of coarse aggregate shall be used for the various classes of concrete previously designated:

Class A.....	No. 4 to 1 $\frac{1}{2}$ inch
Class B.....	No. 4 to 2 $\frac{1}{2}$ inch
Class C.....	No. 4 to 3 inch
Class D.....	No. 4 to $\frac{3}{4}$ inch or No. 4 to 1 $\frac{1}{2}$ inch

If the contractor so elects, the maximum size of the coarse aggregate may be reduced in Class A or B concrete provided the amount of cement used in the mix is increased as directed by the engineer. Such increase shall be at the expense of the contractor. The one and one-half inch maximum size for Class D concrete may be used where the spacing of the reinforcing bars permits.

45.4 Protecting and Sampling Cement. Suitable means of storing and protecting the cement against moisture or other injurious effects shall be provided by the contractor. Sacks of cement which, for any reason, have become partially set or which contain lumps of caked cement shall be rejected and shall be immediately removed from the work.

Different brands of cement shall not be mixed during use or in storage, nor shall they be used alternately in any one class of construction. The same brand and kind of cement shall be used in a given structure above the ground line.

Cement may be sampled at the mill or at the site of the work. The seals of the cars containing the cement which has been sampled shall not be broken except by the engineer. The contractor shall notify the engineer of dates of delivery so that there will be sufficient time for sampling cement either at the mill or upon delivery.

45.5 Storage of Aggregates. The handling and storage of aggregates shall be such as to prevent segregation or the admixture of foreign materials.

If both crushed stone and gravel coarse aggregate are used in any one structure, they shall be stored separately. They shall not be mixed for use in successive batches, nor shall they be used alternately in any structure. Coarse aggregates secured from the same or different sources and which vary widely in gradation, shall be placed in separate stockpiles or bins and recombined in proportions required by the engineer. Different sizes of aggregates shall be stored in separate stockpiles sufficiently removed from each other to prevent the material at the edges of piles from becoming intermixed.

45.6 Equipment. Methods employed in performing the work, and all equipment, tools, and machinery used for handling materials and executing any part of the work, shall be subject to the approval of the engineer. All equipment necessary shall be on hand and approved before concrete operations are begun by the contractor.

Weighing equipment for aggregates shall be accurate within an allowable error of not more than five-tenths percent of all loads. It shall be arranged so as to allow compensation to be made for changes in weight of moisture contained in the aggregates, and to permit the convenient removal of overweight material from the weighing hopper. The scales shall be either of the beam or springless dial type. A suitable device consisting of a graduated beam or dial shall be used to register at least the last 100 pounds of either of the aggregates required for the batch. The value of the minimum graduation shall not be greater than two pounds.

Water measuring equipment shall be capable of accurate measurement with an allowable error of not more than two percent and shall be so arranged that the accuracy of measurement shall not be affected by variations in pressure in the water supply line. The water measuring equipment shall preferably include an auxiliary tank from which the measuring tank shall be filled.

Portland cement concrete shall be mixed in batch mixers of an approved design, which may be either of the revolving drum or pug mill type. The mixer shall be equipped with an approved timing device which will automatically

lock the discharging device so as to prevent the emptying of the mixer until the materials have been mixed the minimum specified time.

Transit type mixers may be used when approved by the engineer. Transit mixers shall be of the revolving drum type, water tight, and so constructed that the concrete can be mixed to insure a uniform distribution of materials throughout the mass. The haul time limit for concrete from the central mixing plant and for transit mixers after the introduction of the mixing water to the batch shall not exceed 30 minutes.

The total volume of material mixed per batch shall not exceed the rated capacity of the mixer.

45.7 Falsework. The contractor shall submit detailed plans for falsework and centering for examination by the engineer. If such plans are not satisfactory to the engineer, the contractor shall make such changes in them as may be required, but it is understood that the engineer's concurrence in the use of the plans as submitted or corrected shall in no way relieve the contractor of responsibility for obtaining satisfactory results. Falsework shall be designed to withstand the superimposed loads due to form work, concrete, and live loads as specified under forms, Article 45.8, without appreciable deformation or settlement. If appreciable settlement occurs in the falsework, the work shall be stopped, any masonry affected shall be removed, and the falsework thoroughly remodeled to insure a first-class product.

Falsework which cannot be founded on a satisfactory footing shall be supported on piling which shall be spaced, driven, and removed in a manner approved by the engineer.

Hardwood wedges or screw jacks shall be used to bring forms or falsework for beams, girders, arch ribs, and other parts of the structure as required, to exact elevation, required camber, and uniform bearing before and during pouring concrete. All wedges shall be double to insure uniform bearing.

Falsework shall be set to give the finished structure the camber specified or indicated on the plans.

45.8 Forms. When requested by the engineer, the contractor shall submit detailed plans for form work for

examination by the engineer. If such plans are not satisfactory to the engineer, the contractor shall make such changes in them as may be required, but it is understood that the engineer's concurrence in the use of the plans as submitted or corrected shall in no way relieve the contractor of responsibility in obtaining satisfactory results.

Forms shall be so designed and constructed that they may be removed without injuring the concrete.

Forms shall be designed to withstand the pressure of the green concrete assuming it to have a horizontal fluid pressure of 85 pounds per foot of depth and a weight of 150 pounds per cubic foot, and in addition, a live load of 50 pounds per square foot on horizontal surfaces.

All forms shall be mortar tight, true to line and elevation, and rigidly braced. Timber forms for exposed finished surfaces shall be lined with plywood, hard pressed fiber board, or other approved material which will produce smooth surfaces, and joints between the adjacent panels of the lining shall be carefully filled with plastic wood or putty or shall be covered with heavy waterproof adhesive paper. Forms for surfaces which will not be exposed shall be constructed of tongue and groove or ship-lap lumber or of a smooth surfaced material as in the case of exposed finished surface. The unsupported length of wooden columns and compression members shall not exceed 15 times the diameter or least side.

Forms shall be properly braced and tied together with approved tie rods so arranged that when the forms are removed no metal will be within one-half inch of any exposed surface.

Forms shall be filleted at all sharp corners. Triangular molding used for fillets shall have two equal sides. In general, the width of the equal sides of moldings shall be three-fourths inch; for the opening through spindle hand rails, construction joints in the hand rail coping, and similar light construction, the width shall be one-half inch; for massive work, such as heavy pier copings, the width shall be one and one-half to two inches.

When concrete is placed in excavation, forms shall be provided for all vertical surface unless otherwise ordered by the engineer. On thin walls, such as abutments, wing

walls, and retaining walls, the forms on one face shall be built up as the concrete is poured, but only to such elevation as will permit proper placing and thorough spading, and in no case greater than the height which can be placed in one day's run. Ports shall be provided in high, thin walls to permit thorough cleaning before placing concrete.

If the forms develop any defects, such as bulging or sagging, after the concrete has been poured, that portion of the work shall be removed and reconstructed, as directed by the engineer, without additional compensation to the contractor. The interior surface of forms shall be adequately oiled or greased to insure the nonadhesion of mortar.

During the erection and after the completion of the forms, they shall be protected in such manner as to preclude shrinkage, warping, curling, and distortion. Form lumber used a second time shall be free from bulge or warp and shall be thoroughly cleaned.

The foregoing specifications shall also apply to metal forms. The metal shall be of such thickness that the forms will remain true to shape. Clamps, pins, or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or line up properly shall not be used. Special care shall be exercised to keep metal forms free from rust, grease, or other foreign matter which would discolor the concrete.

Forms for concrete over or in the vicinity of operating railroads shall be so constructed and placed that standard clearances demanded by the railroad company will be maintained at all times.

45.9 Proportioning. All aggregates for use in Portland cement concrete shall be proportioned by weight, with the exception that aggregates for culvert headwalls, short pieces of curb or small sections of sidewalk and related minor work may be proportioned either by weight or by volume as the contractor may elect. Measuring boxes of known capacity shall be furnished and used to measure each size of aggregate proportioned by volume.

The engineer, subject to the requirements tabulated

herein, shall fix and designate respective amounts of materials to be used in the mix for each class of concrete, including the amount of water. The sum of the weights of fine and coarse aggregate designated for each class shall equal the weights shown in the total aggregate column for the respective types of material. Within the range of the tabulation, the engineer shall designate the proportions of fine aggregate which, using the materials furnished, will produce a workable mix of the consistency herein specified with the least amount of water. If, during construction, concrete at any time is found unsatisfactory, the contractor shall readjust his batch, subject to the requirements tabulated below, as ordered by the engineer, until the mix actually being used on the job complies with all requirements.

The contractor shall combine the cement, water, fine aggregate, and coarse aggregate into uniform batches, by incorporating into each batch the number of bags of cement and amount of water designated by the engineer, and weighing into each batch the respective weights of fine and coarse aggregate designated by the engineer in accordance with the following tabulation:

Class	Coarse Aggregate Used	WEIGHT OF FINE AGGREGATE		Aggregate Per Bag of Cement, Pounds	Total Weight		
		—PER BAG OF CEMENT—					
		Minimum, Pounds	Maximum, Pounds				
A	Gravel	180	220	580			
A	Stone	216	264	580			
B	Gravel	184	218	640			
B	Stone	230	282	640			
C	Gravel	230	282	800			
C	Stone	288	352	800			
D	Gravel	138	169	480			
D	Stone	174	214	480			

For each class the pounds of coarse aggregate shall be the difference between the pounds shown in the total aggregate column and the pounds of fine aggregate as fixed and designated. The above tabulation is based on an apparent specific gravity of 2.65 for both fine and coarse aggregate.

Corrections shall be made for variations therefrom, in job materials, of more than 0.05 up or down. The weights are based on dry aggregates.

No change in the source, character, or grading of materials shall be made without due notice to the engineer, and no work shall proceed using such changed or new materials, or using any materials not possessing all the qualities and properties upon which the designated mix and proportions have been based, until the engineer has duly determined and designated an appropriate mix based on the new or altered material.

45.10 Batching. Concrete of the class indicated shall be made up of accepted materials furnished by the contractor, and shall be batched in proportions set by the engineer for the specific materials in accordance with the foregoing composition requirements.

Quantities of each ingredient for the batch size to be used shall be set by the engineer and not changed except upon his order. The exact amount of each ingredient so set shall be incorporated in each batch. Corrections based upon laboratory determinations, necessitated by the variations from day to day in the moisture content of the raw materials or for other similar reasons, shall be made as directed by the engineer.

Coarse and fine aggregate shall be handled and measured separately. No batch shall be run requiring fractional bags of cement. Cement shall be measured by the bag as packed by the manufacturer. Each bag shall contain 94 pounds net and shall be emptied directly into the charging skip of the mixer. Water shall be measured either by volume or by weight.

45.11 Consistency. The consistency of the various classes of concrete, when determined by the slump test in accordance with the Standard Method of Slump Test for Consistency of Portland Cement Concrete, A. S. T. M. C-143, shall be within the following range:

Class A	1 to $2\frac{1}{2}$ inches
Class B	1 to 3 inches
Class C	1 to 2 inches
Class D	1 to 4 inches

The above ranges represent the extreme limits of allowable slump. In all cases the amount of water used, as determined by the engineer, shall be the minimum necessary to secure the required workability of the concrete.

45.12 Mixing. Unless otherwise authorized, concrete shall be machine mixed at the site. Concrete shall be thoroughly mixed in a batch mixer of an approved size and type. It shall be mixed only in such quantities as are required for immediate use, and any which has developed an initial set, or which is not in place in the forms within 30 minutes after the water has been added, shall not be used. No retempering of the concrete shall be allowed. Concrete shall be thoroughly mixed for a period of not less than one and one-quarter minutes after all materials, including water, are in the mixer. During such period, the mixer shall be operated at speeds specified by the manufacturer. The entire contents of the mixer shall be removed before materials for the succeeding batch are placed therein. Concrete mixed in transit mixing equipment shall be agitated continuously after mixing starts until it is all discharged from the drum.

In no case shall the mixer be loaded in excess of its rated capacity. The first batch of concrete materials placed in the mixer shall contain an additional quantity of sand, cement, and water sufficient to coat the inside surface of the drum without diminishing the mortar content of the mix. Upon cessation of mixing for any considerable length of time the mixer shall be thoroughly cleaned.

45.13 Hand Mixing. Hand mixing shall not be permitted, except in case of an emergency, in which case the following method shall be used: The materials shall be mixed on a watertight level platform. The proper amount of coarse aggregate shall be measured in measuring boxes and spread on the platform and the sand shall be spread on this layer, the two layers being not more than one foot in depth. On this shall be spread the dry cement and the whole turned with shovels not less than two times dry; then the whole mass shall be sprinkled or sprayed with sufficient clean water evenly distributed, and again turned

with shovels not less than three times, not including shoveling into the wheel barrow or forms. Hand-mixed batches shall not exceed one cubic yard in volume.

45.14 Handling and Placing Concrete. In preparation for the placing of concrete, all sawdust, chips, and other construction debris and extraneous matter shall be removed from the interior of the forms. Dimensions affecting the construction of subsequent portions of the work shall be carefully checked before any concrete is placed. Concrete shall be placed so as to avoid segregation of the materials and displacement of the reinforcement.

The use of long chutes for conveying concrete from the mixer to the forms will not be permitted. Troughs, pipes, or short chutes used as aids in placing concrete shall be arranged and used in such a manner that the ingredients of the concrete are not separated. Where steep slopes are required, the chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement. When pipes are used they shall be kept full of concrete and have their lower ends kept buried in fresh concrete in the same manner that a tremie is used. All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. Water used for flushing shall be discharged clear of the concrete in place.

Dropping the concrete a distance of more than five feet or depositing a quantity at any one point and running or working it along the forms will not be permitted. Placing of concrete shall be so regulated that the pressures caused by the wet concrete shall not exceed those used in the design of the forms. Special care shall be taken to fill each part of the forms by depositing concrete directly as near final position as possible, to work the coarser aggregates back from the face, and to force the concrete under and around the reinforcement bars without displacing them. After the concrete has taken its initial set, care shall be exercised to avoid jarring the forms or placing any strain on the ends of projecting reinforcements.

All concrete shall be compacted by means of high frequency internal vibrators of a type approved by the engineer, with the exception that pipe culvert headwalls, curb and

gutter, sidewalk, and related minor structures may be compacted by hand methods. The minimum frequency of the vibrators shall be not less than 4,500 impulses per minute. The intensity of vibration shall be such as to visibly affect a mass of concrete of one inch slump over a radius of at least 18 inches. The number of vibrators employed shall be ample, as determined by the engineer, to consolidate the incoming concrete to the proper degree within 15 minutes after it is deposited in the forms. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and into corners and angles of the forms. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. Vibrators shall be inserted and drawn out of concrete slowly. The vibration shall be of such duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall be supplemented by such spading as is necessary to insure smooth surfaces and dense concrete along the form surfaces and in corners and locations impossible to reach with a vibrator.

The placing of concrete shall be done in such manner that the reinforcing steel is not coated with cement before its final embedment. In depositing concrete around steel shapes and closely spaced reinforcing bars, the concrete shall be deposited on one side of the steel and worked until it flushes under the steel to the opposite side before any concrete is placed on the opposite side or over the steel.

When existing walls are faced and raised with concrete, or where walls or columns support slabs or beams, the concrete in the vertical member shall be deposited up to the bottom of the supported member, and a period of at least 12 hours shall elapse for settlement before placing concrete in the horizontal member. In the construction of box culverts four feet or less in height, the side walls and top slab may be constructed as a monolith. When this method of construction is used, any necessary construction joints shall be vertical and at right angles to the axis of the culvert.

In the construction of box culverts more than four feet in height the concrete in the walls shall be placed and allowed to set before the top slab is placed. In this case

appropriate keys shall be left in the side walls for anchoring the cover slab.

Concrete shall be placed in each predetermined portion of the work in a continuous operation to avoid stoppage planes. The contractor shall furnish sufficient equipment, mixer capacity, and working force to accomplish this. Concrete shall be deposited in horizontal layers, placing thin layers at first that can be thoroughly worked into intimate contact with the concrete beneath it. After a depth of six inches has been built up in this manner, the thickness of layers may be increased to a maximum of 12 inches. The depth of layers used shall be such that the succeeding layer will be placed before the previous layer has attained initial set. Each layer shall be compacted in a manner that will break up and obliterate any tendency to form a plane of separation between the layers. If it is necessary, by reason of an emergency, to stop placing concrete before any section is completed, bulkheads shall be placed as the engineer may direct. Any place where the placing of concrete is discontinued for a sufficient time to allow the concrete to take initial set shall be deemed a construction joint and treated as herein described. After the concrete in the finished surface has begun to set, it shall not be walked upon or otherwise disturbed in less than 48 hours.

Concrete preferably shall be deposited by beginning at the center of the span and working from the center towards the ends. Concrete in girders shall be deposited uniformly for the full length of the girder and brought up evenly in horizontal layers. Concrete in slab spans shall be placed in one continuous operation for each span.

Each beam, between the limits shown on the plans or directed by the engineer, shall be cast in one continuous operation. The top of the concrete shall be kept level and it shall be placed in layers, the thickness of which shall be proportioned to the rate of delivery of the concrete to the forms, so that there will be no planes of initial set in any part of the unit. All key-ways, seats for secondary beams, dowels, and bars that connect the beams with other units of the work shall be in place before the placing of concrete is commenced.

Concrete in beams or deck girder spans may be placed

in one continuous operation or may be placed in two separate operations, each of which shall be continuous; first, to the top of the girder stems, and second, to completion. In the latter case, the bond between stem and slab shall be positive and mechanical and shall be secured by means of suitable shear keys with or without dowels in the top of the girder stem. The size and location of these keys and dowels shall be computed. In general, suitable keys may be formed by the use of timber blocks approximately two inches by four inches in cross section and having a length four inches less than the width of the girder stem. These key blocks shall be placed along the girder stem as required, but the spacing shall not be greater than one foot center to center. The blocks shall be beveled and oiled in such manner as to insure their ready removal.

Concrete in columns shall be placed in one continuous operation, unless otherwise directed. The columns shall be allowed to set at least 12 hours before the caps are placed. No concrete shall be placed in a superstructure until the column forms have been stripped sufficiently to determine the character of the concrete in the columns. The load of the superstructure shall not be allowed to come upon the bents until they have been in place at least 21 days, unless otherwise permitted by the engineer.

Concrete in arch rings shall be placed in such a manner as to load the centering symmetrically. The centering shall be weighted if necessary to prevent distortion. Arch rings shall be divided into sections of such size that, when working simultaneously at points symmetrically located about the crown, the sections can be cast in one continuous operation without permitting the formation of planes of initial set. The sections shall be bonded together by suitable keys or dowels. Adequate struts shall be provided to resist any unbalanced thrusts to piers in structures composed of more than one span. The size, arrangement, and sequence of placing concrete sections of all arches shall be subject to the approval of the engineer.

Concrete shall not be exposed to the action of water before setting, or deposited in water, except with the approval of the engineer and under his immediate supervision. When concrete is so deposited, the method and

manner of placing shall be as hereinafter designated. All concrete deposited under water shall be mixed in the proportions designated for Class D concrete having a minimum slump of six inches. Concrete deposited under water shall be carefully placed in a compacted mass in its final position by means of a tremie, a bottom dump bucket, or other approved method, and shall not be disturbed after being deposited. Special care must be exercised to maintain still water at the point of deposit. No concrete shall be placed in running water, and all form work designed to retain concrete under water shall be watertight. The consistency of the concrete shall be carefully regulated and special care shall be exercised to prevent segregation of the materials. The method of depositing concrete shall be so regulated as to produce approximately horizontal surfaces. Each seal shall be placed in one continuous operation.

When a tremie is used, it shall consist of a tube having a diameter of not less than 10 inches, constructed in sections having flanged couplings fitted with gaskets. The means of supporting the tremie shall be such as to permit the free movement of the discharge end over the entire top surface of the work, and shall be such as to permit its being rapidly lowered when necessary to choke off or retard the flow. The discharge end shall be entirely sealed at all times and the tremie tube kept full to the bottom of the hopper. When a batch is dumped into the hopper the tremie shall be slightly raised, but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper. The flow is then stopped by lowering the tremie. Pouring shall be continuous and in no case shall it be interrupted until the work is completed.

When concrete is placed by means of a bottom dump bucket, the bucket shall have a capacity of not less than one-half cubic yard. The bucket shall be lowered gradually and carefully until it rests upon the concrete already placed. It shall then be raised very slowly during the discharge travel, the intent being to maintain, as near as possible, still water at the point of discharge and to avoid agitating the mixture.

45.15 Cyclopean Concrete. Cyclopean concrete shall consist of either class B or class C concrete, as specified, containing large embedded stones. It shall be used only with the approval of the engineer or if called for on the plans, in massive piers, gravity abutments or walls, and heavy footings. The stone for this class of work may be one-man stone or derrick stone conforming to the requirements of Section 78.

The stone shall be carefully placed, not dropped or cast, so as to avoid injury to the forms or to the partially set adjacent masonry. Stratified stones shall be placed upon the natural bed. All stone shall be washed and saturated with water before placing.

The total volume of the stone shall not be greater than one-third of the total volume of the portion of the work in which it is used. For walls or piers greater than two feet in thickness, one-man stone may be used; each stone shall be surrounded by at least six inches of concrete and no stone shall be closer than one foot to any top surface nor closer than six inches to any coping. For walls or piers greater than four feet in thickness, derrick stone may be used; each stone shall be surrounded by at least one foot of concrete and no stone shall be closer than two feet to any top surface nor closer than eight inches to any coping.

45.16 Joints. All planes where work is temporarily stopped shall be deemed joints, and shall be treated by one of the following methods:

Construction joints where the placing of concrete is delayed until the concrete has taken its initial set and for which no expansion is provided, shall be planned in advance and shall be subject to approval by the engineer. The placing of concrete shall be continuous from joint to joint. These joints shall be perpendicular to the principal lines of stress and, in general, located at points of minimum shear. No concrete work shall be stopped or temporarily discontinued within 18 inches of the top of any finished surface, unless such work is finished with a coping having a thickness less than 18 inches, in which case, the joints shall be made at the underline of the coping. A joint not shown on the plans will not be permitted in a cantilevered member. Horizontal

joints in piers and abutments, except where specified, shall generally be avoided, and when used shall not be located within two feet of the normal water level.

All construction joints shall be made with bulkheads provided with keyways whose areas are approximately one-quarter of the cross-sectional area of the joint. When making a horizontal construction joint, care shall be taken to have the concrete as dry as possible, and any excess water or creamy material shall be drawn off before the concrete sets. On all exposed surfaces, the line of the proposed joint shall be made truly straight by tacking a temporary straight-edge on the inside of the form and pouring the concrete so that it will set flush with the edge as provided.

Construction joints not shown on the plans and above ordinary low water, in abutments and retaining walls that retain earth fills, shall be waterproofed on the back with a 36-inch strip of waterproofing, as directed by the engineer, at the contractor's expense.

In resuming work, the surface of the concrete previously placed shall be thoroughly cleaned of dirt, scum, laitance, or other soft or porous material with a stiff wire brush to expose the sound aggregate beneath, and, if deemed necessary by the engineer, shall be roughened with a steel tool. The surface then shall be thoroughly washed with clean water and painted with a thin coat of neat cement mortar, and the forms tightened to close contact with the previously placed work, after which the concreting may proceed.

When the work is unexpectedly interrupted by breakdowns, storm, or other causes, and the concrete as placed would produce an improper construction joint, the contractor shall either rearrange the freshly deposited concrete, or continue by hand mixing, if necessary, until a suitable arrangement is made for a construction joint. When such a joint occurs at a section on which there is shearing stress, he shall provide adequate mechanical bond across the joint by inserting reinforcing steel, or by some other means satisfactory to the engineer, which will prevent a plane of weakness.

Expansion joints shall be filled with an approved pre-molded filler, unless otherwise shown on the plans. The

thickness of the joints shall be as indicated on the plans. The joint filler shall be cut to the same shape as the area to be covered, but one-quarter inch smaller on all surfaces that will be exposed in the finished work. It shall be firmly fixed against the surface of the concrete already in place in such manner that it will not be displaced when the fresh concrete is deposited against it. Where necessary to use more than one piece to cover any surface, the joint between separate pieces shall be covered with a layer of two-ply roofing felt, one side of which shall be covered with hot asphalt to insure proper retention. The one-quarter-inch space along the edges at exposed surfaces shall be filled with wooden strips of the same thickness as the joint material. These wooden strips shall be saturated with oil and have sufficient draft to make them readily removable after the concrete is placed. Immediately after the forms are removed the expansion joint shall be carefully inspected. Any concrete or mortar that has sealed across the joint shall be neatly cut and removed.

Sliding joints shall be true planes parallel to the direction of the movement. Where sliding joints are to be provided at the ends of slabs, girders, beams, or between walls, etc., the surface of the supporting concrete shall be given a smooth finish and covered with two layers of three-ply roofing felt to separate the concrete.

Special joints, watertight and flashed, shall be constructed as shown on the plans.

45.17 Cold Weather Operations. No concrete shall be mixed or placed when the atmospheric temperature is below 35° F. without written permission of the engineer, and only when adequate means are employed to heat the aggregate and water and protect the concrete from freezing after being placed. Sufficient heating apparatus, such as stoves, salamanders, or steam equipment, and fuel to furnish all required heat, shall be supplied. All water used for mixing concrete shall be heated to a temperature of at least 70° F., but not over 150° F. Aggregates shall be heated either by steam or by dry heat to a temperature of at least 70° F., but not over 150° F. The heating apparatus shall be such as to heat the mass uniformly and preclude the possibility of hot

spots which will burn the material. The temperature of the mixed concrete shall not be less than 60° F. nor more than 100° F. at the time of placing in the forms.

When directed by the engineer, the contractor shall furnish sufficient canvas and frame work, or other type of housing, to enclose and protect the structure in such a way that the air surrounding the fresh concrete can be kept at a temperature above 50° F. for a period of five days after the concrete is placed. If Type III cement is used, this period may be reduced as directed by the engineer.

The contractor shall assume all risk in the placing of concrete in cold weather, and permission given to place concrete under the above conditions shall in no way relieve the contractor of responsibility for proper results. Should concrete placed under such conditions prove unsatisfactory, it shall be removed and replaced at the contractor's expense.

45.18 Curing. Freshly poured concrete shall be kept continuously wet for a period of not less than seven days by covering with heavy absorbent mats or wet earth, by ponding, or by continuous sprinkling. If Type III cement is used, the curing period may be reduced as directed by the engineer. When absorbent mats are used, they shall be wet sufficiently to keep the surface adjacent to the concrete surface moist at all times. After the period of water curing, concrete surfaces shall be protected from the direct rays of the sun for an additional three days. During this time the surfaces may be allowed to dry out slowly. In no case shall alternate wetting and drying of the concrete be permitted. In cold weather the period of curing shall be extended as directed by the engineer.

Absorbent mats for curing concrete shall consist of two layers of fabric with a cotton bat filler. The fabric shall be of a quality and texture to readily permit absorption of water by the bat. The cotton bat shall be made of raw cotton, cotton comber waste, cotton card strip waste, or other approved material, and shall weigh not less than 12 ounces per square yard. The mat shall be tufted or quilted to insure an even distribution of the bats within the fabric layers.

When required by the special provisions or approved in

writing by the engineer, structures or portions of structures as specified may be cured by means of an approved impervious membrane.

The membrane shall consist of a practically colorless impervious liquid of a type approved by the engineer. Any membrane material which would alter the natural color of the structure will not be permitted.

The liquid shall be applied under pressure with a spray nozzle in such a manner as to cover the entire surface to be cured with a uniform film, and shall be of such character that it will harden within 30 minutes after application. The amount of liquid applied shall be ample to seal the surface thoroughly. Application of the liquid shall be made immediately after forms are removed and finishing operations have been completed. Prior to the application of the liquid the concrete shall be protected and kept moist as required herein.

45.19 Removal of Falsework and Forms. In the determination of the time for removal of falsework, forms, and housing, and the discontinuance of heating, consideration shall be given to the location and character of the structure, the weather and other conditions influencing the setting of the concrete, and the materials used in the mix.

In general, the forms of any portions of the structure shall not be removed until the concrete gives forth a clear, sharp ring when struck upon a flat surface with a small hammer, and is strong enough to prevent injury to the concrete when the forms are removed. This test is not applicable to frozen concrete.

Methods of form removal likely to cause overstressing of the concrete shall not be used. In general, the forms shall be removed from the bottom upwards. Forms and their supports shall not be removed without the approval of the engineer. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

When required by the engineer, field operations shall be controlled by beam and cylinder tests and the removal of forms, supports, and housing, and the discontinuance of heating and curing may be begun when the modulus of

rupture or the compressive strength reaches the value which shall be fixed by the engineer for the particular method of testing which is to be used. The beams or cylinders shall be cured under conditions which are not more favorable than the most unfavorable conditions for the portions of the concrete which the specimens represent.

If the field operations are not controlled by beam or cylinder tests, the following period, exclusive of days when the temperature is below 40 degrees, shall apply to removal of forms:

Arch centers.....	21 days
Centering under beams.....	21 days
Floor slabs	21 days
Walls	5 days
Columns	10 days
Sides of beams and all other parts.....	7 days

If Type III cement is used, this period may be reduced as directed by the engineer.

In order to make possible the obtaining of a satisfactory surface finish, forms for ornamental work, railings, and parapets shall be removed in not less than 12 nor more than 48 hours depending upon the weather conditions.

Forms shall always be removed from columns before removing shoring from beneath beams and girders in order to determine the condition of the concrete in the columns.

No superimposed load, either live or dead, shall be allowed upon the structure within the period for which the falsework is required to remain in place. Falsework and centering for arches shall not be struck until the fill back of the abutments has been placed up to the spring line. Falsework for rigid frame structures shall not be removed until the fill has been placed back of the vertical legs as specified in Section 21.

45.20 Patching. The presence of excessive honeycombed areas shall be considered sufficient cause for the rejection of the structure, and upon written notice from the engineer, the contractor shall remove and rebuild the structure in part or in whole as specified, at his own expense. In patching holes or porous spots, all coarse or broken material shall be chipped away until a dense, uniform surface

of concrete exposing solid coarse aggregate is obtained. Feather edges shall be cut away to form a face perpendicular to the surface being patched. All surfaces of the cavity shall be thoroughly saturated with water, after which a thin layer of neat cement mortar shall be applied. The cavity shall then be filled with thick, dry mortar composed of one part of Portland cement to three parts of sand, which shall be thoroughly tamped into place. The surface of this mortar shall be floated with a wooden float before the initial set takes place, and shall present a neat and workmanlike appearance of the same color as the remainder of the structure. The patch shall be kept continuously wet for a period of five days. For patching large or deep areas, coarse aggregate shall be added to the patching material, if ordered by the engineer, and special precautions shall be taken to insure a dense, well bonded and properly cured patch as required by the engineer.

45.21 Finishing. All concrete surfaces shall be reasonably true and even, free from stone pockets, excessive depressions, or projections beyond the surface. Concrete floors shall be struck off with a template before the concrete has set, to provide the proper crown, and shall be hand finished to a smooth even surface by means of both longitudinal and transverse wooden floats, or other suitable means. The finished surface shall not show variations of over one-eighth inch in 10 feet, using a straightedge 10 feet long placed parallel to the center line of the roadway, and no variation shall be permitted that will tend to prevent complete drainage of all parts of the deck. Concrete bridge-seats and tops of walls and curbs shall be brought flush with the finished top surface and struck off with a straight-edge and floated.

When so ordered by the engineer, all exposed surfaces, which shall include bottom of overhung or cantilever portions of slabs; bottom, and outside of exterior beams or girders; faces of abutments, piers, or walls above a point one foot below the ground or fill line; and all sides of curbs, hand railings, columns, arch ribs, and struts shall be finished by rubbing with a carborundum stone.

The entire surface to be finished shall be thoroughly wet

and rubbed with a No. 16 carborundum stone, or an abrasive of equal quality, bringing the surface to a paste. The rubbing shall be continued sufficiently to remove all form marks and projections, producing a smooth dense surface without pits or irregularities. The material which, in the above process, has been ground to a paste, shall be carefully spread or brushed uniformly over the entire surface and permitted to reset. The final finish shall be obtained by thorough rubbing with a No. 30 carborundum stone or an abrasive of equal quality. This rubbing shall continue until the entire surface is of a smooth texture and uniform in color. Immediately following the rubbing process, the finished surface shall be thoroughly washed with water. A cement wash or plaster coat shall not be used.

45.22 Waterproofing. Concrete surfaces shall be waterproofed where and as designated on the plans.

45.23 Drainage and Weep Holes. Drainage and weep holes shall be constructed in the manner and where indicated on the plans or directed by the engineer. Drainage and weep holes in the faces of abutments shall be connected with roadway drains wherever indicated on the plans. Ports or vents for equalizing hydrostatic pressure shall be placed below low water. Weep holes shall be placed at the elevations shown on the plans or as directed by the engineer.

45.24 Method of Measurement. The quantity to be paid for shall be the number of cubic yards of concrete, of the several classes, complete in place and accepted. In computing the concrete yardage for payment, the dimensions used shall be those shown on the plans or ordered in writing by the engineer. No measurements or other allowances will be made for work or material for forms, falsework, cofferdams, pumping, bracing, etc.

If the proposal contains such an item, concrete hand railing, including concrete posts, shall be measured in linear feet, in the completed and accepted work, in which case no allowance shall be made for the yardage contained in the railing.

45.25 Basis of Payment. The yardage, determined as provided above, shall be paid for at the contract unit price

per cubic yard for "Class A Concrete," "Class B Concrete," "Class C Concrete," "Class D Concrete," or "Cyclopean Concrete" as the case may be. If such an item is shown in the proposal form, concrete railing shall be paid for at the contract unit price per linear foot for "Concrete Rail." Such payment shall be full compensation for the concrete; for all materials including expansion joint filler, timber bumpers, forms, falsework, placing, and finishing; and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the item. Reinforcing steel, including drains, water stops, and expansion joint angles, when there is no item for structural steel in the proposal, shall be measured and paid for as specified in Section 46.

SECTION 46—REINFORCING STEEL

46.1 Description. This item shall consist of furnishing and placing in concrete, reinforcing steel of the quality, type, size, and quantity designated, all as required by these specifications and as shown on the plans.

46.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Bar reinforcement.....	Section 92
Mesh reinforcement.....	Section 92

46.3 Bending Diagrams. When bar bending diagrams are not shown on the plans, order lists and bending diagrams shall be furnished by the contractor for approval by the engineer, and no material shall be shipped until such lists and bending diagrams have been approved. The approval of order lists and bending diagrams by the engineer shall in no way relieve the contractor of responsibility for the correctness of such lists and diagrams. Any expenses incident to the revision of materials furnished in accordance with such lists and diagrams to make them comply with the design drawings shall be borne by the contractor.

46.4 Protection of Material. Steel reinforcement shall be protected at all times from injury. When placed in the work, it shall be free from dirt, detrimental scale, paint, oil, or other foreign substances. However, when steel has on its surface, rust, loose mill scale, or dust which is easily removable, it may be cleaned by a satisfactory method, if approved by the engineer.

46.5 Fabrication. Bent bar reinforcement shall be cold bent to the shape shown on the plans; and, unless otherwise provided on the plans or by authorization, bends shall be made in accordance with the following requirements:

Stirrups and tie bars shall be bent around a pin having a diameter not less than two times the minimum thickness of bar. Bends for other bars shall be made around a pin having a diameter not less than six times the minimum thickness, except that for bars larger than one inch the bend shall be made around a pin of eight bar diameters.

Reinforcing bars shall be cut and bent at the mill or shop

before shipment to the work. Bending in the field will not be permitted except to correct errors, deformations due to handling, or minor omissions in shop fabrication.

Bar reinforcement shall be shipped in standard bundles, tagged and marked in accordance with the Code of Standard Practice of the Concrete Reinforcement Steel Institute.

46.6 Mesh Reinforcement. Mesh reinforcement, when specified, shall conform to the requirements of Section 92 and shall be fabricated as shown on the plans.

46.7 Placing and Fastening. All steel reinforcement shall be accurately placed in the positions shown on the plans and firmly held during the placing and setting of concrete. When placed in the work, it shall be free from dirt, rust, mill scale, paint, oil, or other foreign material. Bars shall be tied at all intersections except where spacing is less than one foot in each direction, when alternate intersections shall be tied.

Distances from the forms shall be maintained by means of stays, blocks, ties, hangers, or other approved supports. Blocks for holding reinforcement from contact with the forms shall be precast mortar blocks of approved shape and dimensions or approved metal chairs. Metal chairs which are in contact with the exterior surface of the concrete shall be galvanized. Layers of bars shall be separated by precast mortar blocks or by other equally suitable devices. The use of pebbles, pieces of broken stone or brick, metal pipe, and wooden blocks shall not be permitted. Unless otherwise shown on the plans, the minimum distance between bars shall be one and one-half inches. Reinforcement in any member shall be placed, and then inspected and approved by the engineer, before the placing of concrete begins. Concrete placed in violation of this provision may be rejected and its removal required.

If mesh reinforcement is shipped in rolls, it shall be straightened into flat sheets before being placed.

46.8 Splicing. All reinforcement bars shall be furnished in the full lengths indicated on the plans. Splicing of bars, except where shown on the plans, will not be permitted without the written approval of the engineer. Splices shall be staggered as far as possible. Unless otherwise shown on the plans, bars shall be lapped 45 diameters to make the splice.

In lapped splices, the bars shall be placed in contact and wired together. Welding of reinforcing steel shall be done only if detailed on the plans or authorized by the engineer in writing. Welding shall conform to the specifications for Welded Highway and Railway Bridges of the American Welding Society.

Sheets of mesh reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The edge lap shall not be less than one mesh in width.

46.9 Substitutions. Substitution of different size bars will be permitted only with specific authorization by the engineer. If steel is substituted, it shall have an area equivalent to the design area or larger.

46.10 Method of Measurement. The quantity of bar reinforcing steel to be paid for shall be the total weight in pounds actually in place, as shown on the plans or revised by the authority of the engineer, based on calculated weights shown in the table below. The quantity of mesh reinforcement to be paid for shall be the total weight in pounds, computed from the theoretical dimensions as shown on the plans. The weight paid for in either case shall not include the extra metal used when bars larger than those specified are substituted by permission of the engineer, the extra metal necessary for splices not indicated on the plans, nor weight of any device used to support or fasten the steel in its correct position. In the case of structures of reinforced concrete where there is no proposal item for structural steel, such minor metal parts as expansion joints, bolts, drains, and the like shall, unless otherwise specified, be measured as reinforcement.

If such an item is shown in the proposal form, the quantity of mesh reinforcement to be paid for shall be the number of square yards computed by multiplying the width of the section to be reinforced by its length. No allowance shall be made for laps.

The calculated weights of plain and deformed bars shall be based on the following table:

Size	Weight Per Foot
$\frac{1}{4}$ inch round	0.167 lbs.
$\frac{3}{8}$ inch round	0.376 lbs.
$\frac{1}{2}$ inch round	0.668 lbs.
$\frac{1}{2}$ inch square	0.850 lbs.
$\frac{5}{8}$ inch round	1.043 lbs.
$\frac{3}{4}$ inch round	1.502 lbs.
$\frac{7}{8}$ inch round	2.044 lbs.
1 inch round	2.670 lbs.
1 inch square	3.400 lbs.
$1\frac{1}{8}$ inch square	4.303 lbs.
$1\frac{1}{4}$ inch square	5.313 lbs.

46.11 Basis of Payment. Reinforcing steel, measured as provided above, shall be paid for at the contract unit price per pound for "Reinforcing Steel," which price shall be payment in full for furnishing the fabricated and bent material, placing, material used for fastening the steel in place, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the installation of the steel in the structure, as specified herein.

If such an item is provided in the proposal form, mesh reinforcement shall be paid for at the contract unit price per square yard for "Mesh Reinforcement," which price shall be full compensation for furnishing the mesh, placing, material used for fastening mesh in place, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the installation of the mesh.

SECTION 47—STRUCTURAL STEEL

47.1 Description. This item shall consist of furnishing, fabricating, preparing, erecting, and painting all structural steel, rivet and eyebar steel, steel forgings, castings, and other metal of the type, shape, dimensions, and quality, required by these specifications or as shown on the plans.

47.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Structural, rivet and eyebar steel....	Section 90
Steel forgings.....	Section 91
Steel castings.....	Section 91
Gray iron castings.....	Section 91
Malleable castings.....	Section 91
Wrought iron.....	Section 91
Bronze.....	Section 91
Sheet copper.....	Section 91
Paints and paint materials.....	Section 106

47.3 Shop and Mill Inspection. Ample notice must be given the engineer by the contractor regarding the source of materials and the name and location of the fabricating company in order to allow for arrangement for both mill and shop inspection of all materials and fabrication. No material shall be manufactured or work done in the shop before arrangements for adequate inspection have been completed. The engineer shall have full access at all times to all parts of the shop and mill where material under his inspection is being manufactured. The acceptance of any material or finished members shall not be a bar to their subsequent rejection if found defective.

The contractor shall furnish the engineer with three copies of mill orders and shipping statements. The weights of the individual members shall be shown on the statements.

47.4 Test Specimens. The contractor shall furnish test specimens as required free of charge.

47.5 Shop Plans. The contractor shall furnish the engineer with all shop detail plans required for fabrication of the steel. The original drawings may be made either on paper or on cloth, but the details must be drawn in ink so

that the prints will be clear and legible. Shop drawings shall be 22 inches by 36 inches in size. Only complete sets of drawings, which have been checked, will be accepted for approval. Casting details, however, may be submitted for approval previous to the other details. Shop plans shall follow the design plans and the required strength shall be developed as shown in the plans and specifications. When submitting shop plans for approval, four sets of shop plans shall be furnished the engineer, who will return one set either approved or with corrections marked thereon. After the plans have been approved, five sets of shop plans and the original tracings or Van Dyke negatives thereof shall be furnished the engineer. All shop plans shall be submitted for approval at least 15 days before fabrication is started and no material shall be fabricated until the plans have been finally approved by the engineer.

47.6 Changes and Substitutions. No changes shall be made in any drawing after it has been approved except by the consent or direction of the engineer in writing.

Substitutions of sections having different dimensions from those shown on the plans shall be made only when approved in writing by the engineer. Should the substitution of heavier members be allowed upon the contractor's request, no extra weight will be allowed over the original design section.

47.7 Methods and Equipment. Before starting the work of erection, the contractor shall inform the engineer fully as to the method of erection he proposes to follow, and the amount and character of equipment he proposes to use, which shall be subject to the approval of the engineer. The approval of the engineer shall not be considered as relieving the contractor of the responsibility for the safety of his methods or equipment or from carrying on the work in full accordance with the plans and specifications. No work shall be done until such approval by the engineer has been obtained.

47.8 Quality of Workmanship. Workmanship and finish shall be equal to the best general practice in modern bridge shops.

47.9 Finish. Finished members shall be true to line and free from twists, bends, and open joints. Portions of the

work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping shall be done carefully and accurately.

47.10 Storage. Structural material, either plan or fabricated, shall be stored at the bridge shop above the ground upon platforms, skids, or other supports. It shall be kept free from dirt, grease, and other foreign matter and shall be protected as far as practicable from corrosion. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection.

47.11 Handling. The loading, transporting, and unloading of structural material shall be conducted so that the metal will be kept clean and free from injury.

47.12 Straightening. Rolled material, before being laid off or worked, must be straight. If straightening is necessary, it shall be done by methods that will not injure the metal. Sharp kinks and bends shall be cause for rejection of the material.

The straightening of plates and angles or other shapes shall be done by methods not likely to produce fracture or other injury. The metal shall not be heated unless permitted by the engineer, in which case the heating shall not be to a higher temperature than that producing a dark cherry red color. After heating, the metal shall be cooled as slowly as possible.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture.

47.13 Rivet Holes. Unless otherwise specified, holes in all field connections and field splices of main truss or arch members, continuous beam spans, plate girders, and rigid frames shall be subpunched and reamed while assembled in the shop.

All holes for floor beams and stringer field end connections shall be subpunched and reamed to a steel template.

All holes for rivets shall be either punched or drilled. Material forming parts of a member composed of not more than five thicknesses of metal may be punched one-sixteenth

of an inch larger than the nominal diameter of the rivets whenever the thickness of the metal is not greater than three-fourths inch for structural steel or five-eighths inch for alloy steel. When there are more than five thicknesses or when any of the main material is thicker than three-fourths inch in structural steel, or five-eighths inch in alloy steel, all the holes shall be subpunched or subdrilled one-eighth inch smaller and, after assembling, reamed one-sixteenth inch larger, or drilled from the solid to one-sixteenth inch larger than the nominal diameter of the rivets.

If additional subpunching and reaming is required, it shall be specified in the special provisions or on the plans.

47.14 Punched Holes. The diameter of the die shall not exceed the diameter of the punch by more than one-sixteenth inch. If any holes must be enlarged to admit the rivets, they shall be reamed. Holes shall be clean cut, without torn or ragged edges. Poor matching of holes shall be cause for rejection.

All holes punched full size, or subpunched, shall be so accurately punched that after assembling (before any reaming is done) a cylindrical pin one-eighth inch smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75 percent of the contiguous holes in the same plane. If the requirement is not fulfilled, the badly punched pieces shall be rejected. If any hole will not pass a pin three-sixteenths inch smaller in diameter than the nominal size of the punched hole, this shall be cause for rejection.

The accuracy of subdrilled holes shall be the same as required for punched holes.

47.15 Reamed or Drilled Holes. Reamed holes shall be cylindrical, perpendicular to the member and not more than one-sixteenth inch larger than the nominal diameter of the rivets. Where practicable, reamers shall be directed by mechanical means. Drilled holes shall be one-sixteenth inch larger than the nominal diameter of the rivet. Burrs on the outside surfaces shall be removed. Poor matching of holes shall be cause for rejection. Reaming and drilling shall be done with twist drills. If required by the engineer, assembled parts shall be taken apart for removal of burrs caused

by drilling. Connecting parts requiring reamed or drilled holes shall be assembled and securely held while being reamed or drilled and shall be match marked.

When holes are reamed or drilled, 85 percent of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than one-thirty-second inch between adjacent thicknesses of metal.

47.16 Rivets. The size of rivets called for on the plans shall be the size before heating.

Rivet heads shall be of standard shape, unless otherwise specified, and of uniform size for the same diameter of rivet. They shall be full, neatly made, concentric with rivet holes, and in full contact with the surface of the member.

Field rivets shall be furnished in excess of the nominal number required to the amount of 10 percent plus 10 rivets for each diameter and length.

47.17 Shop Riveting. Rivets shall be heated uniformly to a light cherry red color and shall be driven while hot. Any rivet whose point is heated more than the remainder shall not be driven. When a rivet is ready for driving, it shall be free from slag, scale, or other adhering matter. Any rivet which, in the opinion of the engineer, is scaled excessively, shall be rejected.

All rivets that are loose, burned, badly formed, or otherwise defective shall be removed and replaced with satisfactory rivets. Any rivet whose head is deficient in size or whose head is driven off center will be considered defective and shall be removed. Stitch rivets that are loosened by the driving of adjacent rivets shall be removed and replaced with satisfactory rivets. Caulking or recupping of rivet heads will not be permitted.

Shop rivets shall be driven by direct-acting rivet machines when practicable. Approved beveled rivet sets shall be used for forming rivet heads on sloping surfaces. When the use of a direct-acting rivet machine is not practicable, pneumatic hammers of approved size shall be used. Pneumatic bucking tools will be required when, in the opinion of the engineer, the size and length of the rivets warrant their use.

Rivets may be driven cold provided their diameter is not over three-eighths inch.

47.18 Shop Assembling. Unless otherwise authorized by the engineer, each individual (full length) truss, arch, continuous beam, or girder shall be assembled in the shop before reaming is commenced. The assembly, including camber, alignment, accuracy of holes and milled joints, shall be approved by the engineer before reaming is commenced.

Complete shop assembly of an entire structure, including floor system, which may be necessary in the case of complicated design or of skewed or superelevated structures, shall be done only if required by the special provisions.

Surfaces of metal in contact shall be cleaned before assembling. The parts of a member shall be assembled, well pinned, and firmly drawn together with bolts before reaming or riveting is commenced. Assembled pieces shall be taken apart, if necessary, for the removal of burrs and shavings produced by the reaming operation. The member shall be free from twists, bends, and other deformations.

Preparatory to the shop riveting of full-size punched material, the rivet holes, if necessary, shall be spear-reamed for the admission of the rivets. The reamed holes shall not be more than one-sixteenth of an inch larger than the nominal diameter of the rivets.

End connection angles, stiffener angles, and similar parts shall be carefully adjusted to correct positions and bolted, clamped, or otherwise firmly held in place until riveted.

Parts not completely riveted in the shop shall be secured by bolts insofar as practicable, to prevent damage in shipment and handling.

The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. If any holes must be enlarged to admit the rivets, they shall be reamed.

Connecting parts assembled in the shop for the purpose of reaming holes in field connections shall be match-marked, and a diagram showing such marks shall be furnished to the engineer.

47.19 Field Riveting. Pneumatic hammers shall be used for field riveting, except when the use of hand tools is permitted by the engineer. Rivets larger than seven-eighths inch in diameter shall not be driven by hand. Cup-faced

dollies, fitting the head closely to insure good bearing, shall be used. Connections shall be accurately and securely fitted up before the rivets are driven. Drifting shall be only such as to draw the parts into position and not sufficient to enlarge the holes or distort the metal. Unfair holes shall be reamed or drilled. Rivets shall be heated uniformly to a light cherry red color and shall be driven while hot. They shall not be overheated or burned. Rivet heads shall be full and symmetrical, concentric with the shank, and shall have full bearing all around. They shall not be smaller than the heads of the shop rivets. Rivets shall be tight and shall grip the connected parts securely together. Caulking or recupping will not be permitted. In removing rivets, the surrounding metal shall not be injured; if necessary, they shall be drilled out.

47.20 Bolts and Bolted Connections. Bolted connections shall not be used unless shown on the plans. Where bolted connections are permitted, the bolts furnished shall be unfinished bolts (ordinary rough or machine bolts). Turned bolts shall be provided if shown on the plans or required by the special provisions. Special ribbed drive fit bolts may be substituted for turned bolts upon written approval of the engineer.

Unfinished bolts shall be standard bolts with hexagonal heads and nuts. The diameter of the bolt holes shall be one-sixteenth inch greater than the diameter of the bolts used. Bolts transmitting shear shall be threaded to such a length that not more than one thread will be within the grip of the metal. The bolts shall be of such length that they will extend entirely through their nuts, but not more than one-fourth inch beyond them. The number of bolts furnished shall be five percent more than the actual number shown on the plans for each size and length. In bolted connections, the nut shall be drawn up tight and set by center punching the threads of the bolt at the face of the nut.

Holes for turned bolts shall be carefully reamed and the bolts turned to a drawing fit with the threads entirely outside of the holes and a washer shall be used. Heads and nuts shall be hexagonal.

One-fourth inch nut locks shall be used on all turned bolts unless otherwise specified on the plans. Turned bolts shall be finished with a finishing cut.

Special ribbed bolts, with drive fit, shall be used only when called for on the plans. Ribbed bolts may be substituted for field rivets in locations where, in the opinion of the engineer, it is impractical to drive rivets. Holes for special ribbed bolts shall be truly cylindrical. The size of holes shall be one-sixteenth inch greater than the nominal diameter of the bolts and shall make a driving fit with the bolts. Holes shall be at right angles to the surface of the metal so that both head and nut will bear squarely against the metal. Bolts shall be driven accurately into the holes without damaging the thread. A snap shall be used to prevent damaging the heads. Heads and nuts shall be drawn tight against the work with a suitable wrench not less than 15 inches long. Bolt heads shall be tapped with a hammer while the nut is being tightened. Where bolts are to be used in beveled surfaces, beveled washers shall be provided to give full bearing to the head and nut. Ribbed bolts shall be furnished in the same number and in nominal sizes not smaller than the rivets for which they are substituted. They shall be furnished in a sufficient variety of lengths so that, when drawn tight, the fluted shank will fill the hole in the work, and the thread will completely fill the nut with not more than one thread protruding. All bolts shall have cut threads neatly and accurately finished. If for any reason the bolts twist before drawing tight, the hole shall be carefully reamed and the bolt replaced with a new bolt of diameter to fit properly in the hole. The contractor shall provide and supply himself with oversize bolts for this replacement in an amount not less than ten percent of the number of ribbed bolts specified.

47.21 Field Assembling. The parts shall be accurately assembled as shown on the plans and any match-marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering which will injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Unless erected by the cantilever method, truss spans shall be erected on blocking so placed as to give the trusses proper camber. The blocking shall be left in place until the tension cord splices are fully riveted and all other

truss connections pinned and bolted. Rivets in splices of butt joints of compression members and rivets in railings shall not be driven until the span has been swung. Splices and field connections shall have one-half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before riveting. Splices and connections carrying traffic during erection shall have three-fourths of the holes so filled.

Fitting-up bolts shall be of the same nominal diameter as the rivets, and cylindrical erection pins shall be one thirty-second inch larger.

47.22 Flame Cutting. Steel or wrought-iron may be flame cut, provided a smooth surface is secured by the use of a mechanical guide. Flame cutting by hand shall be done only where approved by the engineer and the surface shall be made smooth by planing, chipping, or grinding. The cutting flame shall be so adjusted and manipulated as to avoid cutting beyond the prescribed lines. Reentrant cuts shall be filleted to a radius of not less than one-half inch.

47.23 Edge Planing. Sheared edges of plates more than five-eighths inch in thickness and carrying calculated stress shall be planed to a depth of one-quarter inch. Reentrant cuts shall be filleted before cutting.

47.24 Facing of Bearing Surfaces. The top and bottom surfaces of steel slabs and base plates and cap plates of columns and pedestals shall be planed, or else the plates or slabs hot-straightened. Parts of members in contact with them shall be faced.

Sole plates of beams and girders shall have full contact with the flanges. Sole plates and masonry plates shall be planed or hot-straightened. Cast pedestals shall be planed on surfaces to be in contact with steel and shall have the surface to be in contact with the masonry, rough finished.

Surfaces of bronze bearing plates intended for sliding contact shall be finished.

In planing the surface of expansion bearings, the cut of the tool shall be in the direction of the expansion.

47.25 Abutting Joints. Abutting joints in compression members and girder flanges, and in tension members where so specified on the drawings, shall be faced and brought to

an even bearing. Where joints are not faced, the opening shall not exceed one-eighth inch.

47.26 End Connection Angles. Floor beams, stringers, and girders having end connection angles shall be built to exact length back to back of connection angles. If end connections are faced, the finished thickness of the angles shall not be less than that shown on the detail drawings.

47.27 Lacing Bars. The ends of lacing bars shall be neatly rounded unless another form is required.

47.28 Web Plates. In girders having no cover plates and not to be encased in concrete, the top edge of the web plate shall not extend above the backs of the flange angles and shall not be more than one-eighth inch below at any point. Any portion of the plate projecting beyond the angles shall be chipped flush with the backs of the angles. Web plates of girders having cover plates may be one-half inch less in width than the distance back to back of flange angles.

Splices in webs of girders without cover plates shall be sealed on the top by welding.

At web splices, the clearance between the ends of the web plates shall not exceed three-eighths inch. The clearance at the top and bottom ends of web splice plates shall not exceed one-fourth inch.

47.29 Fit of Stiffeners. End stiffener angles of girders and stiffener angles intended as supports for concentrated loads shall be milled or ground to secure an even bearing against the flange angles. Intermediate stiffener angles shall fit sufficiently tight to exclude water after being painted. Fillers under stiffeners shall fit within one-fourth inch at each end.

Welding will be permitted in lieu of milling or grinding, if noted on the plans or specified in the special provisions.

47.30 Eyebars. Eyebars shall be straight, true to size, and free from twists, folds in the neck and head, and other defects. The heads shall be made by upsetting and rolling or forging, and not by welding. The form of the heads will be determined by the dies in use at the works where the eyebars are made, if they are satisfactory to the engineer. The thickness of the head and neck shall not overrun more than one-sixteenth inch.

Eyebars that are to be placed side by side in the structure shall be bored so accurately that upon being placed together, pins one thirty-second inch less in diameter than the pin holes will pass through the holes at both ends at the same time without driving.

47.31 Annealing. Before boring, eyebars shall be annealed to produce the required physical qualities and shall be straightened. Proper instruments shall be provided for determining at any time the temperature of the bars.

Other steel that has been heated partially shall be annealed, unless it is to be used in minor parts. Crimped stiffeners need not be annealed.

47.32 Pins and Rollers. Pins and rollers shall be accurately turned to the dimensions shown on the drawings and shall be straight, smooth, and free from flaws.

Pins and rollers more than seven inches in diameter shall be forged and annealed. In pins larger than nine inches in diameter, a hole not less than two inches in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling, and before being annealed. Pin holes shall be bored true to the specified diameter, smooth, and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.

The distance outside to outside of holes in tension members and inside to inside of holes in compression members shall not vary from that specified more than one-thirty-second inch. Boring of holes in built-up members shall be done after the riveting is completed.

The diameter of the pin hole shall not exceed that of the pin by more than one-fiftieth inch for pins five inches or less in diameter, or one-thirty-second inch for larger pins.

Screw threads for all bolts and pins for structural steel construction shall conform to the American National Coarse Thread Series, Class 2, free fit, except that pin ends having a diameter of one and three-eighths inches or more shall be threaded six threads to the inch.

Pilot and driving nuts shall be used in driving pins. They shall be furnished by the contractor without charge. Two pilot nuts and two drifting nuts for each size of pin shall be furnished, unless otherwise specified. Pins shall be so driven that the members will take full bearing on them. Pin nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

47.33 Bearing and Anchorage. Masonry bearing plates shall not be placed upon bridge seat bearing areas which are improperly finished, deformed, or irregular. Bearing plates shall be set level in exact position and shall have a full and even bearing upon the masonry. Unless otherwise directed by the engineer, they shall be placed on a layer of canvas and red lead applied as follows:

Thoroughly swab the bridge seat bearing area with red lead paint and place upon it three layers of 12 to 14 ounce duck, each layer being thoroughly swabbed on its top surface with red lead paint. Place the superstructure shoes or pedestals in position while the paint is plastic. As an alternate to canvas and red lead, sheet lead may be used if called for on the plans.

The contractor shall drill the holes and set the anchor bolts, except where the bolts are built into the masonry. The bolts shall be set accurately and fixed with Portland cement grout, completely filling the holes. The location of the anchor bolts in relation to the slotted holes in the expansion shoes shall correspond with the temperature at time of erection. The nuts on anchor bolts at the expansion ends of spans shall be adjusted to permit free movement of the span.

47.34 Misfits. The correction of minor misfits involving nonharmful amounts of reaming, cutting, and chipping shall be considered a legitimate part of the erection. However, any error in the shop fabrication, or deformation resulting from handling and transportation, which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the engineer and his approval of the method of correction obtained. The correction shall be made in his

presence. The contractor shall be responsible for all misfits, errors, and injuries and shall make the necessary corrections and replacements.

47.35 Welding. Structural steel shall not be welded unless called for on the plans or in the special provisions or upon written permission of the engineer, except that minor defects in structural steel may be remedied in accordance with the requirements of Article 90.4. Welding of structural steel when authorized, shall conform to the specifications for Welded Highway and Railway Bridges of the American Welding Society.

47.36 Falsework. All falsework shall be properly designed and substantially constructed and maintained for the loads which will come upon it. The contractor, if required, shall prepare and submit to the engineer, for approval, plans for falsework or for changes in an existing structure necessary for maintenance of traffic. Approval of the contractor's plans shall not be considered as relieving the contractor of any responsibility.

Upon completion of the erection and before final acceptance, the contractor shall remove all falsework, excavated or useless materials, rubbish, and temporary buildings; replace or renew any fences damaged, restore in an acceptable manner all property, both public and private, which may have been damaged during the prosecution of the work, and leave the bridge site and adjacent highway in a neat and presentable condition satisfactory to the engineer.

All excavated material or falsework placed in the stream channel during construction shall be removed by the contractor before final acceptance.

47.37 Marking and Shipping. Each member shall be painted or marked with an erection mark for identification and an erection diagram shall be furnished with erection marks shown thereon. The contractor shall furnish to the engineer as many copies of material orders, shipping statements, and erection diagrams as the engineer may direct. The weights of the individual members shall be shown in the statements. Members weighing more than three tons shall have the weight marked thereon. Bolts and rivets of one length and diameter, and loose nuts or washers of each size, shall be packed separately. Pins, small parts,

and small packages of bolts, rivets, washers, and nuts shall be shipped in boxes, crates, kegs, or barrels, but the gross weight of any package shall not exceed 300 pounds. A list and description of the contained material shall be plainly marked on the outside of each shipping container.

Anchor bolts, washers, and other anchorage or grillage materials shall be shipped in time to suit the requirements of masonry construction.

47.38 Painting. Structural steel, unless otherwise specified, shall be painted as specified in Section 66.

47.39 Method of Measurement. The quantity of structural steel to be paid for under this item shall be the weight of metal in the fabricated structure completed and accepted, which weight shall include the weight of the actual number of field rivets required. The weights of erection bolts, field paint, and all boxes and crates or other containers used for packing, together with sills, struts, and rods used for supporting members during transportation shall be excluded. For the purpose of measurement for payment, steel plates and shapes for pier protection, all metal conduits, scuppers, pipes, and drains in the superstructure, and all zinc and other similar metals required in the superstructure shall be considered as structural steel. Expansion plates and rockers or castings of any kind, regardless of the type of material specified, shall also be considered as structural steel.

The weight to be paid for shall be the shop scale weight unless otherwise provided. Finished work shall be weighed in the presence of the engineer's shop inspector. The contractor shall supply satisfactory scales and shall perform all work involved in handling and weighing the various parts. When it is not practicable to obtain the shop scale weights of the individual members in the presence of the inspector, and it is so ordered, payment will be based on the computed weight. In any case, if the total scale weight of any member exceeds the computed weight by more than one and one-half percent, the weight in excess of one and one-half percent over the computed weight shall not be paid for. If the scale weight of any member is more than two and one-half percent less than the computed weight, the member may be rejected.

Weights shall be computed on the following basis:

(a) Unit weights per cubic foot in pounds:

Aluminum, cast or wrought.....	173
Bronze, cast.....	536
Copper alloy.....	536
Copper sheet.....	558
Iron, cast.....	445
Iron, malleable.....	470
Iron, wrought.....	487
Lead, sheet	707
Steel, cast, copper bearing, carbon, silicon, nickel and stainless.....	490
Zinc	450

(b) The weights of rolled shapes, and of plates up to and including 36 inches in width, shall be computed on the basis of the nominal weights and dimensions, as shown on the approved shop drawings, deducting for copes, cuts, and all open holes, except rivet holes. To the nominal weights of plates more than 36 inches in width, there shall be added one-half the allowed percentage of overrun in weight given in the Standard Specifications for Steel for Bridges and Buildings, A. S. T. M. Serial Designation A-7.

(c) Weights of all rivet heads, both field and shop, shall be included on the basis of the following weights:

Diameter of rivets, inches	Weight per 100 heads, pounds
$\frac{1}{2}$	4
$\frac{5}{8}$	7
$\frac{3}{4}$	12
$\frac{7}{8}$	18
1	26
$1\frac{1}{8}$	36
$1\frac{1}{4}$	48

(d) The weight of castings shall be computed from the dimensions shown on the approved shop drawings, deducting for open holes. To this weight shall be added ten percent allowance for fillets and overrun.

(e) To the total computed weight of the metal shall be added four-tenths of one percent for an allowance for shop paint.

(f) The weight of steel or brass shims required shall be

included. The weight of brass shims shall be calculated on the basis of unit weight of brass.

If the proposal contains such an item, structural steel railing shall be measured in linear feet between concrete posts in the completed and accepted work.

47.40 Basis of Payment. The weight, determined as provided above shall be paid for at the contract unit price per pound for "Structural Steel." If such an item is shown in the proposal form, structural steel railing shall be paid for at the contract unit price per linear foot for "Structural Steel Rail." Such payment shall be full compensation for furnishing, fabricating, delivering, erecting, and painting, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the item, including furnishing of mill test reports and test specimens, except specimens for full-size tests, in accordance with the plans and these specifications.

Full size eyebars or members which are tested and meet the requirements of these specifications shall be paid for at the same rate as for the structure. Bars which fail to meet these requirements, and all bars rejected as a result of tests, shall not be paid for.

SECTION 48—TIMBER STRUCTURES

48.1 Description. This item shall consist of furnishing, framing, and installation of timber of the kind, sizes, and dimensions, and in accordance with the lines, grades, and sections shown on the plans.

48.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Structural, rivet and eyebar steel	Section 90
Steel castings	Section 91
Gray iron castings	Section 91
Wrought iron	Section 91
Hardware	Section 93
Timber	Section 100
Timber preservative	Section 102
Paints and paint materials	Section 106

48.3 Material Lists. If material lists or order lists are sent by the contractor to the engineer for checking or approval, such checking or approval by the engineer shall in no way relieve the contractor of responsibility for the correctness of such lists. Any expenses incident to the revision of materials furnished in accordance with such lists to make them comply with the design drawings shall be borne by the contractor.

48.4 Inspection. The contractor shall furnish an inspection certificate from either the West Coast Bureau of Timber Grades and Inspection, the Pacific Lumber Inspection Bureau, the California Redwood Association, or the Port Orford Cedar Lumber Association, with each shipment of lumber, whether treated or untreated.

When treated Douglas fir is specified, the contractor shall inform the engineer of the name of the plant at which timber is to be treated, sufficiently far in advance of starting the work, in order that arrangements may be made for the inspection of treatment. The contractor shall furnish facilities for the inspection of material and workmanship, and the inspector shall be allowed free access to the necessary parts of the plant.

48.5 Storage of Materials. Lumber and timber on the site of the work shall be stored in piles.

Untreated material shall be open-stacked at least 12 inches above the ground surface and piled to shed water and prevent warping. When required by the engineer it shall be protected from the weather by suitable covering.

Creosoted timber and piling shall be close-stacked and piled to prevent warping, and the tops of the stacks shall be covered with a two-inch layer of earth.

The ground underneath and in the vicinity of all material piles shall be cleared of all weeds and rubbish.

48.6 Workmanship. Workmanship shall be first class throughout. None but competent bridge carpenters shall be employed, and all framing shall be true and exact. Unless otherwise specified, nails and spikes shall be driven with just sufficient force to set the heads flush with the surface of the wood. Deep hammer marks in wood surfaces shall be considered evidence of poor workmanship and sufficient cause for removal of the workman causing them. The workmanship on all metal parts shall conform to the requirements specified in Section 47, Structural Steel.

48.7 Treated Timber. Treated timber and piling shall be carefully handled without sudden dropping, breaking of the outer fibers, bruising, or penetrating the surface with tools. It shall be handled with rope slings. Cant hooks, peaveys, pikes, or hooks shall not be used.

All cutting, framing, and boring of treated timbers shall be done before treatment, insofar as is practicable.

All cuts in treated piles or timbers, and all abrasions, after being carefully trimmed, shall be covered with two applications of a mixture of 60 percent creosote oil and 40 percent roofing pitch or brush coated with at least two applications of hot creosote oil and covered with hot roofing pitch.

All bolt holes bored after treatment, shall be treated with creosote oil by means of an approved pressure bolt hole treater. Unfilled holes, after being treated with creosote oil, shall be plugged with creosoted plugs.

Whenever, with the approval of the engineer, forms or temporary braces are attached to treated timber with nails or spikes, the holes shall be filled by driving galvanized nails

or spikes flush with the surface or plugging holes as required for bolt holes.

48.8 Untreated Timber. In structures of untreated Douglas fir the following surfaces shall be thoroughly coated with two coats of hot creosote oil before assembling: Ends, tops, and all contact surfaces of sills, caps, floors, and stringers; and all ends, joints, and all contact surfaces of bracing and truss members. The back faces of bulkheads and all other timber which is to be in contact with earth, metal, or other timber shall be similarly treated.

Unless untreated timber is to be used in the construction within three days after date of delivery, it shall be painted on each end with a prime coat at time of delivery.

48.9 Holes for Bolts, Dowels, Rods, and Lag Screws. Holes for round drift-bolts and dowels shall be bored with a bit one-sixteenth inch less in diameter than the bolt or dowel to be used. The diameter of holes for square drift-bolts or dowels shall be equal to the least dimension of the bolt or dowel.

Holes for machine bolts shall be bored with a bit of the same diameter as the bolt.

Holes for rods shall be bored with a bit one-sixteenth inch greater in diameter than the rod.

Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread.

48.10 Bolts and Washers. A washer, of the size and type specified, shall be used under all bolt heads and nuts which would otherwise come in contact with wood.

All bolts shall be effectively checked after the nuts have been finally tightened.

48.11 Countersinking. Countersinking shall be done whenever smooth faces are required. Horizontal recesses formed for countersinking shall be painted with hot creosote oil, and, after the bolts are screwed in place, shall be filled with hot pitch.

48.12 Framing. All lumber and timber shall be accurately cut and framed to a close fit in such manner that the joints will have even bearing over the entire contact surfaces. Mortises shall be true to size for their full depth and tenons

shall fit snugly. No shimming will be permitted in making joints, nor will open joints be accepted.

Mud sills shall be firmly and evenly bedded to solid bearing and tamped in place.

Concrete pedestals for the support of framed bents shall be carefully finished so that the sills or posts will take even bearing on them. Dowels or straps for anchoring sills or posts, as indicated on the plans, shall be set in them when they are cast.

Sills shall have true and even bearing on mud sills, piles, or pedestals. They shall be drift-bolted to mud sills or piles with bolts extending into the mud sills or piles at least six inches, as indicated on the plans. When possible, all earth shall be removed from contact with sills so that there will be free air circulation around them.

Posts shall be fastened to pedestals with dowels or straps as shown on the plans. Posts shall be fastened to sills as indicated on the plans.

48.13 Caps. Timber caps shall be placed to secure an even and uniform bearing over the tops of the supporting posts or piles and to secure an even alignment of their ends. All caps shall be secured by drift-bolts, as indicated on the plans, extending at least nine inches into the posts or piles. Drift-bolts shall be approximately in the center of the post or pile.

48.14 Bracing. The ends of bracing shall be bolted through the pile, post, or cap with a bolt of not less than five-eights inch diameter. Intermediate intersections shall be bolted, and spiked with wire or boat spikes, as indicated on the plans. In all cases spikes shall be used in addition to bolts.

48.15 Stringers. Stringers shall be sized at bearings and shall be placed in position so that knots near edges will be in the top portions of the stringers.

Outside stringers may have butt joints with the ends cut on a taper, but interior stringers shall be lapped to take bearing over the full width of the floor beam or cap at each end. The lapped ends of untreated stringers shall be separated at least one-half inch for the circulation of air and shall be

securely fastened by drift-bolts where specified. When stringers are two panels in length the joints shall be staggered.

Cross-bridging between stringers shall be neatly and accurately framed and securely toe-nailed with at least two nails at each end. All cross-bridging members shall have full bearing at each end against the sides of stringers. Unless otherwise specified in the contract, cross-bridging shall be placed at the center of each span.

48.16 Plank Floors. Unless otherwise specified, flooring plank shall be surfaced one side and one edge. Single plank floors shall consist of a single thickness of plank supported by stringers or joists. The plank shall be laid heart side down with one-quarter inch openings between them for seasoned material and with tight joints for unseasoned material. Each plank shall be securely spiked to each joist. The plank shall be carefully graded as to thickness and so laid that no two adjacent planks will vary in thickness more than one-sixteenth inch.

Two-ply timber plank floors shall consist of two layers of flooring supported on stringers or joists. The lower course shall be pressure-treated with a creosote oil. The top course may be laid either diagonal or parallel to the center line of the roadway, as specified, and each floor piece shall be securely fastened to the lower course. Joints shall be staggered at least three feet. If the top flooring is placed parallel to the center line of the roadway, special care shall be taken to securely fasten the ends of the flooring. At each end of the bridge these members shall be beveled.

48.17 Laminated Floors. Laminated floors shall be composed of three by six inch or two by six inch timbers, as indicated on the plans, laid on edge at right angles to the center line of the roadbed, unless otherwise shown on the plans.

The flooring may be of random length and multiples of the stringer spacing with no single piece less than six feet long. All splices shall be made on the center line of a stringer and shall not occur oftener than once in six inches on any one stringer.

Laminations shall be laid with a finished edge down. Before laying, the tops of stringers shall be checked with a straightedge and adjacent stringers which vary more than

one-eighth inch from a true plane, except treated stringers, shall be surfaced to meet this requirement. Treated stringers which do not meet the requirement may be rejected but shall not be framed or adzed after treatment. Each piece of flooring shall be fastened to the preceding strip at each end and at approximately 18-inch intervals with spikes or nails driven alternately near the top and bottom edges. Spikes or nails shall be of sufficient length to pass through two strips and at least half-way through the third strip. If timber supports are used, each piece shall be toe-nailed to every other support with 20d or 30d nails. Care shall be taken to have each strip vertical and tight against the preceding one, and bearing evenly on all supports.

48.18 Wheel Guards and Railing. Wheel guards and railing shall be accurately framed in accordance with the plans and erected true to line and grade. Unless otherwise specified, wheel guards shall be surfaced one side and one edge (S1S1E) and rails and rail posts shall be surfaced on four sides (S4S). Wheel guards shall be laid in sections not less than 12 feet long.

48.19 Trusses. Trusses, when completed, shall show no irregularities of line. Chords shall be straight and true from end to end in horizontal projection and, in vertical projection, shall show a smooth curve through panel points conforming to the correct camber. All bearing surfaces shall fit accurately. Uneven or rough cuts at the points of bearing shall be cause for rejection of the piece containing the defect.

Unless otherwise directed by the engineer, housings and railings shall be built after the removal of the falsework and the adjustment of the trusses to correct alignment and camber.

48.20 Painting. Outside stringers, wheelguards, rails, rail posts, and exposed surfaces of scupper blocks, filler blocks, and flooring of untreated timber, or timber treated with preservative salts, shall be painted with three coats of paint as specified in Section 66.

Ends of all pieces of untreated timber not otherwise painted shall be painted with one prime coat.

Metal parts, except hardware, shall be given one coat of shop paint, and, after erection, two coats of field paint, as specified in Section 66.

48.21 Method of Measurement. Timber shall be measured by the number of thousand feet, board measure, remaining in place in the completed and accepted structure, based on the nominal dimensions.

If the proposal contains such an item, laminated timber culvert barrel shall be the actual number of linear feet in the completed and accepted work measured along the axis of the barrel.

48.22 Basis of Payment. The quantity of timber, measured as provided above, shall be paid for at the contract unit price per thousand feet board measure for "Untreated Douglas Fir," "Treated Douglas Fir," "Redwood," or "Port Orford Cedar," as the case may be, complete in place. If such an item is shown in the proposal form, laminated timber culvert barrel shall be paid for at the contract unit price per linear foot for "..... ft. \times ft. Laminated Culvert." Such payment shall be full compensation for furnishing all materials, including hardware, treating when specified, furnishing and applying paint, framing, erecting, and for all labor, material, tools, supplies, equipment, and incidentals necessary to complete the work. The contract price shall include the cost of furnishing inspection certificates. The cost of inspection of creosote treatment shall be borne by the department.

Metal parts, other than hardware shall be measured and paid for as for Structural Steel, Section 47.

SECTION 49—PILING

49.1 Description. This item shall consist of furnishing, driving, and cutting off piling of the kind and dimensions specified. The piles shall conform to and be driven in accordance with these specifications and in the location and to the elevations, bearings, and penetrations shown on the plans or ordered by the engineer.

49.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Steel piles.....	Section 90
Timber piles.....	Section 101
Timber preservative	Section 102

49.3 Treated Piles. When treated piles are required, the preservative treatment shall be as specified in Section 63.

49.4 Inspection. The contractor shall furnish an inspection certificate from either the West Coast Bureau of Timber, Grades and Inspection, or the Pacific Lumber Inspection Bureau with each shipment of timber piling.

When treated Douglas fir is specified, the contractor shall inform the engineer of the name of the plant at which piling is to be treated, sufficiently far in advance of starting work, that arrangements may be made for inspection of treatment. The contractor shall furnish facilities for the inspection of material and workmanship, and the inspector shall be allowed free access to the necessary parts of the plant.

When steel piling is specified the contractor shall furnish the engineer with copies of mill test reports on the steel piling.

49.5 Test Piles. When required, the contractor shall drive test piles of lengths and at the locations designated by the engineer. The locations shall be such that the piles shall be driven in position so that they may be cut off and become a part of the permanent structure. Test piles shall be of the lengths specified on the plans or ordered by the engineer, and shall be long enough to provide for any variation in soil conditions. The remainder of the piling shall not be ordered until the actual lengths required have been determined by means of test piles. The contractor shall furnish piles in

accordance with an itemized list, which shall be furnished by the engineer after test piles have been driven, showing the number and lengths of all piles.

49.6 Preparing Timber Piles. Timber piles shall be carefully handled during and after unloading from cars. They shall not be dragged across the ground at any time and shall be handled only with rope slings or with wooden equipment. Sharp tools shall be permitted only when used for the necessary field cutting and trimming. All places where the surface of treated piling is broken by cutting, boring, or otherwise, shall be thoroughly coated with three applications of hot creosote oil. Each application shall be allowed to become reasonably dry before the succeeding one is applied.

The piles for any one bent shall be carefully selected as to size, to avoid undue bending or distortion of the sway bracing. However, care shall be exercised in the distribution of piles of varying sizes to secure uniform strength and rigidity in the bents of any given structure.

Heads of piles, when the nature of the driving is such as to unduly injure them, shall be protected by caps of approved design, having a rope or other suitable cushion next to the pile head and fitting into a casting which in turn supports a timber shock block. When the area of the head of any timber pile is greater than that of the face of the hammer, a suitable cap shall be provided to distribute the blow of the hammer throughout the cross section of the pile and thus avoid, as far as possible, the tendency to split or shatter the pile.

Collars or bands to protect piles against splitting and brooming shall be provided when necessary. Timber piles shall be pointed where soil conditions require it. When necessary, the piles shall be shod with metal shoes of a design satisfactory to the engineer, the points of the piles being carefully shaped to secure an even and uniform bearing on the shoes.

For steel piling, the heads shall be cut squarely and a driving cap shall be provided to hold the axis of the pile in line with the axis of the hammer.

49.7 Driving Piles. Full length piles shall always be used where practicable, but if splices cannot be avoided an

approved method of splicing shall be used. Piles shall not be spliced except by permission of the engineer.

Piles shall not be driven until after the excavation is completed. Any material forced up between the piles shall be removed to correct elevation before masonry for the foundation is placed. Piles shall be driven with a steam, air, or gravity hammer, or a combination of water jets and hammer.

Gravity hammers for driving timber and steel piles shall weigh not less than 3,000 pounds. The fall shall be so regulated as to avoid injury to the piles, and in no case shall exceed 15 feet. When a steam hammer is used, the total energy developed by the hammer shall be not less than 6,000 foot-pounds per blow. In case the required penetration is not obtained by the use of a hammer complying with the above minimum requirements, the contractor shall provide a heavier hammer, or resort to jetting at his own expense.

Leads shall be used with all types of hammers. Pile driver leads shall be constructed in such a manner as to afford freedom of movement to the hammer, and they shall be held in position by guys or stiff braces to insure support of the pile during driving. Except where piles are driven through water, the leads shall be of sufficient length so that the use of a follower will not be necessary. Preferably, inclined leads shall be used in driving battered piles. The driving of piling with followers shall be avoided, if practicable, and shall be done only under written permission of the engineer. When followers are used, one pile from every group of ten shall be a long pile driven without a follower, and shall be used as a test pile to determine the average bearing power of the group.

When water jets are used, the number of jets and the volume and pressure of water at the jet nozzles shall be sufficient to freely erode the material adjacent to the pile. The plant shall have sufficient capacity to deliver at all times at least 100 pounds per square inch pressure at two three-quarter inch jet nozzles. Before the desired penetration is reached, the jets shall be withdrawn and the piles shall be driven with the hammer to secure the final penetration.

Bearing piles of all types shall be driven with a minimum penetration of 10 feet in the ground and to greater depth if

required on the plans, in the special provisions, or by the engineer.

All piles raised by the driving of adjacent piles shall be driven down again if required by the engineer.

Assembled sections of steel sheet piling shall be water tight.

49.8 Loading Tests and Bearing Values. When required, the size and number of piles shall be determined by actual loading tests. In general, these tests shall consist of the application of a test load placed upon a suitable platform supported by the pile, with suitable apparatus for accurately measuring the test load and the settlement of the pile under each increment of load. In lieu thereof, hydraulic jacks with suitable yokes and pressure gages may be used.

The safe allowable load shall be considered as 50 percent of that load which, after a continuous application of 48 hours, produces a permanent settlement not greater than one-quarter inch measured at the top of the pile. This maximum settlement shall not be increased by a continuous application of the test load for a period of 60 hours or longer.

In the absence of loading tests, a safe bearing value for piles shall be determined by the following formulas:

$$P = \frac{2WH}{S + 1.0} \quad \text{for timber piles driven with gravity hammers.}$$

$$P = \frac{FWH}{S + 0.1H} \quad \text{for steel piles driven with gravity hammers.}$$

$$P = \frac{2WH}{S + 0.1} \quad \text{for steel or timber piles driven with single-acting steam hammers.}$$

$$P = \frac{2H(W + Ap)}{S + 0.1} \quad \text{for steel or timber piles driven with double-acting steam hammers.}$$

where P = safe bearing power in pounds,

W = weight, in pounds, of striking parts of hammer,

H = height of fall in feet,

A = area of piston in square inches,

p = steam pressure in pounds per square inch at the hammer.

S = average penetration in inches per blow for the last 5 to 10 blows for gravity hammers and the last 10 to 20 blows for steam hammers.

F = a constant depending on material encountered.

For piles driven to refusal or in alluvial deposits, soft clays, and silts, $F = 2$. For piles driven in mixed clays and sand, or sand and silt, $F = 3$.

For piles driven in hard or sandy clay, $F = 4$.

For piles in sands or gravels, $F = 6$.

The foregoing formulas are applicable only when—

- (a) The hammer has a free fall.
- (b) The head of the pile is not broomed or crushed.
- (c) The penetration is reasonably quick and uniform.
- (d) There is no sensible bounce after the blow.
- (e) A follower is not used.

Twice the height of the bounce shall be deducted from "H" to determine its value in the formula.

Unless otherwise ordered by the engineer, timber piling shall be driven to the bearing value given on the plans or in the special provisions. If bearing values are not given, timber piling shall be driven to a minimum value of 20 tons.

In case water jets are used in connection with the driving, the bearing power shall be determined by the above formulas from the results of the driving after the jets have been withdrawn, or a load test may be applied.

49.9 Defective Piles. The procedure incident to the driving of piles, shall not subject them to excessive and undue abuse producing injurious splitting, splintering, and brooming of the wood or deformation of the steel. Any pile damaged by reason of internal defects, or by improper driving, or driven out of its location shall be removed or, at the option of the engineer, a second pile may be driven adjacent thereto, if this can be done without detriment to the structure. All piles so driven shall be at the expense of the contractor.

Piles shall be driven with a variation of not more than one-fourth inch per foot from the vertical or from the batter shown on the plans or determined by the engineer. Wooden piles driven below the elevation fixed by the plans or by the engineer shall be withdrawn and replaced by new and, if necessary, longer piles at the expense of the contractor. Steel piles driven below the required elevations shall be spliced as ordered by the engineer.

All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again.

49.10 Cutting Off Piles. Tops of all piling shall be cut off to a true plane, as shown on the plans, and at the elevations fixed by the engineer. Piles which support timber caps or grillage shall be sawed to conform to the plane of the bottom of the superimposed structure. The length of the pile above the elevation of cut-off shall be sufficient to permit the complete removal of all material injured by driving.

49.11 Treatment of Pile Heads. Timber pile heads, after cutting to receive the caps and prior to placing the caps, shall be treated to prevent decay.

The heads of treated timber piles shall be protected by one of the following methods, as specified on the plans. If not otherwise specified, method (b) shall be used.

(a) The sawed surface shall be covered with three applications of a mixture of 60 percent creosote oil and 40 percent roofing pitch or thoroughly brush coated with three applications of hot creosote oil and covered with hot roofing pitch. A sheet of 12-gage zinc shall then be placed on the pile head. The sheet zinc shall be of sufficient size to project at least four inches outside of the pile and it shall be bent down, neatly trimmed, and securely fastened to the faces of the pile with large-headed galvanized roofing nails.

(b) The heads of all piles shall be covered with alternate layers of hot pitch and loosely woven fabric similar to membrane waterproofing, using four applications of pitch and three layers of fabric. The cover shall measure at least six inches more in dimension than the diameter of the pile and shall be neatly folded down over the pile and secured by large-headed galvanized nails or by binding or serving with not less than seven complete turns of galvanized wire securely held in place by large-headed galvanized nails and staples. The edges of the fabric projecting below the wire wrapping shall be trimmed to present a workmanlike appearance.

The above does not apply to pile heads encased in concrete.

49.12 Method of Measurement. Timber and steel bearing piles shall be paid for at the price per linear foot for furnishing piles and the lump sum price per pile for driving.

The length of furnished pile shall be the actual length in linear feet of piling placed in the leads in accordance with the pile order list approved by the engineer.

The number of piles driven shall be the actual number of

piles remaining in the completed structure, irrespective of the length of pile driven.

The quantity of steel sheet piling to be paid for shall be the number of pounds of steel, including wales and tie backs, when shown on the plans, complete in place in the accepted work. No allowance shall be made for material cut off. In calculating the weight, the theoretical weight of the approved section shall be used.

49.13 Basis of Payment. Load tests, when ordered, shall be paid for at the contract unit price each for "Load Tests," which price shall be full compensation for constructing the loading platform, procuring and placing the loading material, disposing of all material upon completion of the tests, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work. When there is no item for this work, it shall be paid for as extra work.

The quantity of piling furnished, measured as provided above, shall be paid for at the contract unit price per linear foot for "Foundation Piles," "Untreated Timber Piles," "Treated Timber Piles," or "Steel Bearing Piles," as the case may be, which price shall be full compensation for furnishing and delivering the piles at the site ready for driving, and shall include the cost of inspection certificates. The cost of inspection of steel piles and creosote treatment for timber piles shall be borne by the department.

The number of bearing piles driven, measured as provided above, shall be paid for at the contract unit price each for "Drive Timber Piles," or "Drive Steel Piles," as the case may be, which price shall be full compensation for preparing, framing, furnishing collars and shoes, driving, jetting, blasting, cutting off, treating pile heads, and for furnishing all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work. In case of steel piles, the contract unit price per pile shall include furnishing and welding pile cap plates as shown on the plans.

The quantity of steel sheet piling, measured as provided above, shall be paid for at the contract unit price per pound for "Steel Sheet Piling," which price shall be full compensation for furnishing and driving the piles, for all excavation, necessary tie-backs and deadmen, except when otherwise shown on the plans, and for furnishing all labor, materials,

tools, supplies, equipment, and incidentals necessary to complete the work.

Test piles shall be measured and paid for in the same manner as specified above for the particular kind of piling.

Necessary splices due to shortness in the approved order list shall be paid for as extra work.

Accepted piles ordered and not driven shall be paid for on the basis of cost plus 15 percent and shall become the property of the department.

Steel shoes, when ordered by the engineer, shall be paid for as extra work. No payment shall be made for trimming the piles and fitting the shoes.

SECTION 50—DRY RUBBLE MASONRY

50.1 Description. This item shall consist of the furnishing and construction of roughly dressed stone, laid without mortar, so as to fit firmly and neatly into such shapes and at such places as are indicated on the plans or ordered by the engineer. Dry rubble masonry as herein specified, shall include the classes commonly known as coursed, random, and random range.

50.2 Materials. All materials shall conform to Part III, Material Details. Specific reference to Part III is as follows:

Stone for masonry.....Section 78

50.3 Laying Stone. The masonry shall be laid to line and in courses roughly leveled up. The bottom or foundation courses shall be composed of large, selected stones and all courses shall be laid with bearing beds parallel to the natural bed of the material. Face joints shall not exceed one inch in width.

Headers shall form at least one-fifth of the exposed faces of walls, shall be uniformly distributed, and shall extend at least 12 inches into the backing. For walls 18 inches or less in thickness, headers shall extend from front to back face. Walls shall have no appreciable open spaces and sufficient spalls shall be used to wedge the larger stones.

In laying dry rubble masonry, care shall be taken that each stone takes a firm bearing at not less than three separate points upon the underlying course. Open joints, both front and rear, shall be "chinked" with spalls fitted to take firm bearing upon their top and bottom surfaces, for the purpose of securing firm bearing throughout the length of the stone.

When required on the plans or in the special provisions, the open joints on the rear surfaces of abutments or retaining walls shall be "slushed" thoroughly with mortar to prevent seepage of water through the joints.

50.4 Copings, Bridge Seats, and Back Walls. Copings, bridge seats, and backwalls, when required, shall be of

Class A concrete conforming to the requirements of concrete structures, or shall conform to the requirements for mortar rubble masonry, as specified.

50.5 Method of Measurement. The quantity of stone masonry to be paid for under this item shall be the number of cubic yards measured in the completed work and the limiting dimensions shall not exceed those shown on the plans or fixed by the engineer. No deductions will be made for weep holes, drain pipes, or other openings of less than two square feet in area.

50.6 Basis of Payment. The quantity, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Dry Rubble Masonry," which price shall be full compensation for furnishing and placing the masonry, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

When concrete or mortar rubble copings, bridge seats, or backwalls are required they shall be measured and paid for as provided under concrete structures, Section 45, or mortar rubble masonry, Section 51.

Necessary excavation shall be measured and paid for as specified under structure excavation, Section 20.

SECTION 51—MORTAR RUBBLE MASONRY

51.1 Description. This item shall consist of the construction of masonry composed of approved stones laid in mortar beds, constructed in such shapes and at such places as are indicated on the plans or ordered by the engineer. Mortar rubble masonry, as here specified, shall include the classes commonly known as coursed, random, and random range.

51.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Stone for masonry.....	Section 78
Mortar sand.....	Section 83
Portland cement	Section 89

51.3 Mortar. Mortar shall be composed of one part of Portland cement and three parts of sand unless otherwise provided. The mortar shall be hand or machine mixed, as may be required by the engineer. In the preparation of hand mixed mortar, the sand and cement shall be thoroughly mixed together in a clean, tight mortar box until the mixture is of uniform color, after which clean water shall be added in such quantity as to make the mortar of such consistency that it can be handled easily and spread with a trowel. Machine mixed mortar shall be prepared in an approved mixer and shall be mixed not less than one and one-half minutes. Mortar that is not used within 45 minutes after water has been added shall be discarded. Retempering of mortar will not be permitted.

51.4 Laying Stone. Mortar rubble masonry shall not be constructed in freezing weather or when the stone contains frost, except by written permission of the engineer and subject to such conditions as he may require.

No masonry shall be placed until the foundation has been checked and approved by the engineer.

The masonry shall be laid to line and in courses roughly leveled up. The bottom or foundation courses shall be composed of large, selected stones and all courses shall be laid with bearing beds parallel to the natural bed of the material.

Each stone shall be cleaned and thoroughly saturated with water before being set, and the bed which is to receive it shall be cleaned and well moistened. All stones shall be well bedded in freshly made mortar. The mortar joints shall be full and the stones carefully settled in place before the mortar has set. No spalls will be permitted in the beds and face joints. Joints and beds shall have an average thickness of not more than one inch.

Headers shall hold in the heart of the wall the same size shown in the face and shall extend not less than 12 inches into the core or backing. They shall occupy not less than one-fifth of the face area of the wall and shall be evenly distributed. Headers in walls two feet or less in thickness shall extend entirely through the wall.

Whenever possible, the face joints shall be properly pointed before the mortar becomes set. Joints which cannot be so pointed shall be prepared for pointing by raking them out to a depth of two inches before the mortar has set. The face surfaces of stones shall not be smeared with the mortar forced out of the joints or that used in pointing.

The vertical joints in each course shall break joints with those in adjoining courses at least six inches. In no case shall a vertical joint be so located as to occur directly above or below a header.

In case any stone is moved or the joint broken, the stone shall be taken up, the mortar thoroughly cleaned from bed and joints, and the stone reset in fresh mortar.

Weep holes shall be provided in all walls and abutments at locations shown on the plans or ordered by the engineer at the lowest points where free outlets can be obtained.

Joints not pointed at the time the stone is laid shall be thoroughly wet with clean water and filled with mortar. The mortar shall be well driven into the joints and finished with an approved pointing tool. The masonry shall be kept wet while pointing is being done and in hot or dry weather the masonry and pointing shall be protected from the sun and kept wet for a period of at least three days after completion.

After the pointing is completed and the mortar set, the wall shall be thoroughly cleaned and left in a neat and workmanlike condition.

51.5 Copings, Bridge Seats, and Backwalls. Copings, bridge seats, and backwalls shall be of the dimensions and materials shown on the plans and when not otherwise specified shall be of Class A concrete which shall conform to the requirements for concrete structures, Section 45.

51.6 Method of Measurement. The quantity of mortar rubble masonry to be paid for shall be the number of cubic yards measured in the completed work and the limiting dimensions shall not exceed those shown on the plans or fixed by the engineer. Copings, bridge seats, and backwalls, except when constructed of concrete, shall be considered as mortar rubble masonry and shall be measured for payment as such.

51.7 Basis of Payment. The quantity of masonry, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Mortar Rubble Masonry," which price shall be full compensation for furnishing and placing the masonry and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

When concrete copings, bridge seats, or backwalls are specified, this part of the work shall be measured and paid for as provided under concrete structures, Section 45.

Necessary excavation shall be measured and paid for as provided under structure excavation, Section 20.

SECTION 52—PIPE CULVERTS

52.1 Description. This item shall consist of furnishing corrugated metal, sectional plate, vitrified clay, and plain or reinforced concrete pipe culverts conforming to these specifications and of the kind, sizes, and dimensions shown on the plans, and installing such pipe where and in conformity with the lines and grades shown on the plans or ordered by the engineer. This item shall also include the furnishing and construction of such joints or connections to existing pipes, catch basins, endwalls, etc., as may be required to complete the work shown on the plans.

52.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Corrugated metal culvert pipe.....	Section 94
Sectional plate culvert pipe.....	Section 95
Vitrified clay culvert pipe.....	Section 96
Reinforced concrete culvert pipe.....	Section 97
Plain concrete culvert pipe.....	Section 98

52.3 Handling Pipe. Culvert pipe shall be carefully handled in unloading, transporting, and laying. Corrugated metal pipe must not have the spelter coat bruised or broken, the metal dented or bent, or the pipe deformed from a straight line or from the true, approved shape. Plain or reinforced concrete and vitrified clay pipe must not show surface chips or hair cracks. Culvert pipes which show defects due to handling shall be rejected at the site of installation regardless of prior acceptance.

52.4 Laying Pipe—General. When pipe is placed in a trench, the width of the trench shall not be greater than necessary to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe, unless otherwise authorized by the engineer.

Pipe shall be bedded in an earth foundation carefully shaped to fit the lower part of the pipe exterior for at least 25 percent of its over-all height. Where rock, in either ledge or boulder formation, is encountered, it shall be removed below grade and replaced with suitable materials in such a manner as to provide a compacted earth cushion

having a thickness under the pipe of not less than one-half inch per foot of height of fill over the top of the pipe, with a minimum allowable thickness of eight inches. Where a firm foundation is not encountered at the grade established, due to soft, spongy, or other unstable soil, all of such unstable soil under the pipe and for a width of at least one diameter on each side of the pipe, shall be removed and replaced with gravel or other suitable material properly compacted to provide adequate support for the pipe.

When shown on the plans or ordered by the engineer, embankments shall be constructed and compacted before excavating trenches for installing pipe culverts. The height to which such embankments are to be built shall be as follows:

Diameter of pipe, inches	Height of fill above pipe, inches
15	12
18	12
24	12
30	15
36	18
48	24

Culverts under the highway shall be placed so that the minimum distance from finished grade to the top of pipe shall be not less than one-half the diameter of full circle pipe or less than one-half the vertical diameter of arch shape pipe with a minimum of one foot.

52.5 Laying Corrugated Metal Pipe. Corrugated metal pipe shall be laid in the trench with the separate sections firmly joined together, with outside laps of circumferential joints pointing upstream, and with longitudinal laps on the sides. Any metal in joints which is not thoroughly protected by galvanizing shall be coated with an approved asphalt paint.

All corrugated metal culverts 48 inches in diameter under embankments 15 feet or over in height, and all culverts over 48 inches in diameter under all heights of embankment shall be jacked out of round and struttured as follows:

After the culvert is placed in the trench, the vertical diameter shall be forced out of round five percent of the nominal diameter, and timber struts placed to retain the

culvert in this position. The struts shall be left in the culvert until the fill has been completed and settlement has taken place. No headwalls shall be placed until struts have been removed and final settlement of the fill has occurred.

52.6 Laying Sectional Plate Pipe. Where sectional plate pipe is to be installed in new embankment, the embankment shall be constructed to the elevation of the third point of the diameter of the pipe, after which the trench shall be excavated and the pipe installed.

Prior to installation, exterior surfaces shall be given a heavy mop coating of approved bituminous material.

Plates forming the bottom of the culvert shall be laid first for the entire length of the pipe beginning at the downstream end. Side and top plates shall then be placed beginning at the upstream end and the work continued until all the plates are in position. Only a sufficient number of bolts shall be placed in each seam to hold the plates in position until the full pipe circle is completely assembled. The remaining bolts shall then be placed and all bolts shall be thoroughly tightened.

In advance of placing backfill, the vertical diameter shall be increased approximately three percent by jacking and inserting struts. Strutting shall be carried uniformly from end to end of pipe for pipes without headwalls. When headwalls are used there shall be no elongation of ends of pipe. The struts shall remain in place until the embankment is complete and compacted or until ordered removed by the engineer.

52.7 Laying Vitrified Clay, Reinforced Concrete, or Plain Concrete Pipe. Proper facilities shall be provided for lowering the sections when they are to be placed in a trench. The pipe shall be laid carefully, hubs upgrade, ends fully and closely jointed, and true to lines and grades as given. Each section shall be securely attached to the adjoining sections. All joints shall be filled with stiff mortar composed of one part Portland cement and two parts sand. The mortar shall be placed so as to form a durable watertight joint. After any section of pipe is laid, and before any succeeding section is laid, the lower portion of the hub of the preceding section shall be plastered thoroughly on the inside with the mortar to such depth as to

bring the inner surfaces of the abutting pipes flush and even. After the section is laid, the remainder of the joint shall be filled with mortar and sufficient additional mortar shall be used to form a bead around the outside of the joint. The inside of the joint shall then be wiped and finished smooth. After the initial set, the mortar on the outside shall be protected from the air and sun with a thoroughly wetted earth or burlap cover. Any pipe which is not in true alignment, or which shows any undue settlement after laying, or is damaged, shall be taken up and relaid without extra compensation.

52.8 Backfilling. Pipe culverts shall be backfilled as specified in Section 21.

52.9 Method of Measurement. The length of pipe culverts to be paid for shall be the actual number of linear feet of culvert in place, but this length shall not be greater than shown on the plans or specified by the engineer. No allowances shall be made for cut-offs on pipes placed on a skew when the pipe is ordered mitered at the factory. When skew cut-offs are ordered in the field, full allowance shall be made for necessary lengths of pipe cut off due to skew.

Sectional plate culvert pipe shall be measured as follows:

Pipes with square and vertical ends, end to end of metal, on center line of structure.

Pipes with skewed and vertical ends, end to end, on center line.

Pipes with square ends, beveled, average end to end at top and bottom of pipe, parallel to center line.

No allowances shall be made for overlaps when lighter gage sections are joined to heavier gage sections to form one continuous culvert.

52.10 Basis of Payment. This item, measured as provided above, shall be paid for at the contract unit price per linear foot for ".....inch Corrugated Metal Pipe," ".....inch by.....inch Corrugated Metal Arch Pipe," ".....inch Sectional Plate Pipe (number of plates and gage)," ".....inch Vitrified Pipe," ".....inch Reinforced Concrete Pipe," ".....inch Plain Concrete Pipe," or ".....inch Corrugated Metal Siphon Pipe," as the case may be, which price shall be full payment for all labor, materials,

tools, supplies, equipment, and incidentals necessary to complete the culvert in accordance with the plans and these specifications, including band couplings or other devices to connect additional lengths to existing culverts.

Necessary excavation shall be measured and paid for as provided under structure excavation, Section 20, except that when embankments are ordered constructed prior to installation of culverts, no quantities shall be measured for payment outside required elevations above the pipe.

Backfill, including the amount necessary to replace excavation below the grade of the pipe when required due to the character of material encountered, shall be paid for as specified under backfill, Section 21.

SECTION 53—RELAYING CULVERT PIPE

53.1 Description. This item shall consist of cleaning and relaying corrugated metal culvert pipe, previously removed, at the points called for on the plans or ordered by the engineer.

53.2 Construction Methods. The pipe shall be thoroughly cleaned to remove all foreign matter. Rust spots shall be thoroughly brushed with a wire brush and such cleaned spots shall be painted with an approved asphalt paint. The pipe shall then be laid in the manner prescribed for setting culvert pipe in Section 52.

53.3 Method of Measurement. The quantity to be paid for shall be the actual number of linear feet of culvert pipe, regardless of the size, relayed in the completed and accepted work.

53.4 Basis of Payment. The quantity of culvert pipe relayed, measured as provided above, shall be paid for at the contract unit price per linear foot for "Relay Culvert Pipe," which price shall be full compensation for cutting to lengths, cleaning and relaying the pipe, for necessary couplings to attach to existing pipes, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

Necessary excavation shall be measured and paid for as provided under structure excavation, Section 20, except that when embankments are ordered constructed prior to installation of culverts, no quantities shall be measured for payment outside required elevations above the pipe.

Backfill, including the amount necessary to replace excavation, below the grade of the pipe when required due to the character of the material encountered, shall be paid for as specified under backfill, Section 21.

SECTION 54—UNDERDRAINS

54.1 Description. This item shall consist of the installation of tile or perforated pipe underdrains, as specified, of the size and at the locations, true to line and grade, shown on the plans or ordered by the engineer.

54.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Gravel for bedding and backfill.....	Section 77
Portland cement	Section 89
Perforated corrugated metal pipe....	Section 94
Drain tile (sewer pipe).....	Section 99

54.3 Trenching. A trench shall be excavated with a minimum width equal to the exterior diameter of the pipe plus 12 inches, and to the depth shown on the plans or ordered by the engineer.

A three-inch bed of clean gravel or broken stone shall be spread in the bottom of the trench throughout its entire length, thoroughly compacted, and brought to a uniform grade. All material excavated from trenches, not required for backfilling, nor usable in the roadway, shall be removed and disposed of by the contractor.

54.4 Laying Pipe. Bell and spigot tile shall be laid upgrade with the bell end upgrade and the spigot end not quite fully entered in the adjacent bell. Pipe shall be laid, true to line and grade, with a uniform bearing under the full length of the barrel. The pipe joints shall then be covered with two-ply tar paper strips not less than six inches in width and of sufficient length to permit the ends being turned outward and laid flat on the bottom course of stone on either side of the pipe for a distance of three inches.

Perforated pipe shall be laid with the perforations at the bottom of the pipe and the sections joined with band couplers. The pipe shall be firmly bedded throughout its length.

54.5 Backfilling. After the pipe has been laid and approved by the engineer, gravel backfill shall be placed

carefully around and over the pipe to within 12 inches of the ground surface. This material shall be placed in layers not exceeding 12 inches in thickness, and each layer shall be thoroughly tamped and compacted with an approved tamping tool. The upper 12 inches of the trench shall then be filled with suitable material of either porous or impervious type, as directed by the engineer, and thoroughly compacted.

If an item for grouting drain backfill is shown in the proposal, gravel backfill which has been thoroughly compacted shall be covered with a thick grout not less than one inch in thickness. The grout shall be composed of one part Portland cement and five parts sand and shall be prepared in accordance with Article 51.3. This grout shall be thoroughly tamped to provide an impervious layer over the entire surface of the gravel backfill.

54.6 Method of Measurement. The length of underdrain to be paid for shall be the actual number of linear feet, measured along its axis, complete in place and accepted.

The quantity of grouted drain backfill to be paid for shall be the actual number of linear feet of drain grouted, measured along the longitudinal axis of the drain, in the completed and accepted work.

The quantity of excavation to be paid for shall be the number of cubic yards removed to the depth specified, except that the width to be paid for shall be limited by vertical surfaces whose distance apart shall be the exterior diameter of the pipe plus 12 inches.

The quantity of gravel bedding and backfill to be paid for shall be the number of cubic yards of backfill complete in place and accepted, except that no quantities shall be paid for outside of vertical planes whose distance apart is equal to the exterior diameter of the drain plus 12 inches. Backfill placed to a depth greater than three inches below the drain shall not be paid for unless ordered by the engineer.

54.7 Basis of Payment. The quantity of underdrain laid, measured as provided above, shall be paid for at the contract unit price per linear foot for ".... inch Tile Underdrain," or ".....inch Perforated Underdrain," as the case may be, which price shall be full compensation for furnishing and installing the pipe, including special sections where

needed, for all connections to existing pipes or structures, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

The quantity of excavation, measured as provided above, shall be paid for as specified under structure excavation, Section 20.

The quantity of bedding and backfill, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Drain Backfill," which price shall be full compensation for stripping pit, crushing, screening, loading, hauling, placing, and tamping backfill and for furnishing all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

The quantity of grouted drain backfill, measured as provided above, shall be paid for at the contract unit price per linear foot for "Grouting Drain Backfill," which price shall be full compensation for furnishing all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 55—HAND-LAID RIPRAP

55.1 Description. This item shall consist of the construction of slope and embankment protection of hand-laid riprap, at the places and of the design and dimensions shown on the plans or ordered by the engineer.

55.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific reference to Part III is as follows:

Stone for masonry.....Section 78

55.3 Construction Methods. Slopes upon which riprap is to be placed shall not be steeper than the angle of repose of the material unless otherwise indicated. Prior to placing the riprap, a foundation trench of sufficient depth to form a stable bed shall be excavated and approved by the engineer. Unless otherwise indicated on the plans or ordered by the engineer, this trench shall extend two feet below the stream bed. Placing of riprap shall commence in the trench and shall progress upward with the larger stones being laid in the lower courses and the smaller stones in the upper courses. The stones shall be placed with their beds at right angles to the slope and shall be laid in such manner that the weight of the stone is carried by the earth and not the adjacent stones. They shall be placed in close contact so as to break joints. The spaces between the larger stones shall be filled with spalls securely rammed into place. The finished surface shall present an even, tight, and reasonably plane surface, varying not more than three inches from the required contour.

55.4 Method of Measurement. The quantity to be paid for shall be the number of cubic yards, measured in place, in the completed and accepted work, except that the dimensions used shall not exceed those shown on the plans or ordered by the engineer.

55.5 Basis of Payment. The yardage, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Hand-laid Riprap," which price shall be full compensation for furnishing and placing all materials, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

Excavation for trenches at toe of slope shall be measured and paid for as specified for structure excavation, Section 20.

SECTION 56—GROUTED HAND-LAID RIPRAP

56.1 Description. This item shall consist of the construction of slope and bank protection of hand-laid riprap with the interstices filled with Portland cement mortar, at the places and of the design and dimensions shown on the plans or ordered by the engineer.

56.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Stone for masonry.....	Section 78
Mortar sand.....	Section 83
Portland cement	Section 89

56.3 Construction Methods. Riprap stone shall be placed in the same manner as specified for hand-laid riprap, Section 55, care being taken to keep earth or sand from filling the spaces between the stones. Weep holes shall be constructed through the riprap, as directed by the engineer. After the stones are in place, the spaces between them shall be completely filled with grout from bottom to top. The grout shall be thoroughly tamped and the surface shall be swept with a stiff broom.

Grout shall consist of one part of Portland cement and three parts of sand, thoroughly mixed with water to produce a grout having a thick, creamy consistency. Grout shall be used within 45 minutes after mixing. Retempering will not be permitted.

Grouted hand-laid riprap shall not be laid in freezing weather, and any work damaged by frost shall be removed and replaced by the contractor at his own expense.

After grouting, the riprap shall be protected from the sun and kept moist for not less than five days.

56.4 Method of Measurement. The quantity to be paid for shall be the number of cubic yards, measured in place, in the completed and accepted work, except that the dimensions used shall not exceed those shown on the plans or ordered by the engineer.

56.5 Basis of Payment. The quantity, measured as provided above, shall be paid for at the contract unit price

per cubic yard for "Grouted Hand-Laid Riprap," which price shall be full compensation for furnishing and placing all materials, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

Excavation for trenches at toe of slope shall be measured and paid for as specified for structure excavation, Section 20.

SECTION 57—MOVING PIPE CULVERT HEADWALLS

57.1 Description. This item shall consist of the removal of existing corrugated metal pipe culvert headwalls and the resetting of the headwalls at the location and to the elevations shown on the plans or ordered by the engineer.

57.2 Construction Methods. Fill shall be removed from around the headwall and for about two feet along the pipe, and the pipe shall be cut smoothly along a plane perpendicular to its center line at a point about one foot back of the headwall. The headwall shall then be removed to its new location, as directed by the engineer, and placed upon a firm foundation excavated to the lines and grades as staked. Care shall be exercised in the moving operation, and any headwall broken or damaged by the contractor's negligence shall be replaced by him at his expense. The section of pipe projecting from the headwall shall be connected with the remainder of the specified length of culvert pipe by means of band couplings to form a continuous culvert having the required grade and alignment. When indicated on the plans or directed by the engineer, the connection shall be made with concrete collars in lieu of band couplings. Backfilling of the headwall in its new position and of the excavation from which it was removed, if required by the engineer, shall be performed as specified for backfill, Section 21.

57.3 Method of Measurement and Basis of Payment. The number of headwalls moved in the completed and accepted work shall be paid for at the contract unit price each for "Move Pipe Culvert Headwalls," which price shall be full compensation for cutting existing pipe, moving and resetting the head walls, including the section of pipe attached to the headwall, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

Excavation necessary for removing and resetting the headwalls shall be measured and paid for as set forth under structure excavation, Section 20.

Backfill shall be measured and paid for as specified in Section 21.

SECTION 58—CONCRETE CURB AND GUTTER

58.1 Description. This item shall consist of concrete curb, concrete gutter, or combined concrete curb and gutter, constructed with Class A concrete in accordance with these specifications, at the locations and of the design and dimensions shown on the plans or ordered by the engineer.

Construction of driveway entrances through curbs shall be considered as included in the work covered by this item.

58.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Coarse aggregate for Portland cement concrete	Section 76
Fine aggregate for Portland cement concrete	Section 81
Portland cement	Section 89
Bar reinforcement	Section 92
Premolded expansion joint filler	Section 105

58.3 Subgrade. Prior to constructing curb and gutter, a satisfactory subgrade shall be prepared true to lines and grades established by the engineer. All soft and unsuitable material in the subgrade shall be removed and replaced with suitable material. The subgrade shall be thoroughly watered and compacted by rolling or hand tamped until hard and smooth.

The completed subgrade shall be tested for grade and cross section by means of a template extending the full depth of the form and supported between the forms.

When indicated on the plans or ordered by the engineer, a layer of approved, thoroughly compacted porous material shall be placed under the curb and gutter.

58.4 Forms. Forms shall be of metal or wood, straight and free from warp, and of sufficient strength to resist springing during the placing of concrete. Timber forms, if used, shall be surfaced on the face which is placed next to the concrete and on the top edge and shall be not less than one and five-eighths inches thick after being surfaced.

Forms shall be of a depth equal to the full depth of the

curb and gutter. They shall be securely staked, braced, and tied together with clamps and spreaders to insure rigidity, and shall be sufficiently tight to prevent leakage of mortar. All forms shall be thoroughly cleaned and oiled before placing concrete. Curb returns shall be rigidly formed and the use of light metal or wood will not be permitted.

58.5 Drainage Openings. Drainage openings, of the size required, shall be made through the curb and gutter where indicated or directed.

58.6 Joints. Curb and gutter shall be constructed in uniform sections ten feet in length except where shorter sections are necessary for closures. The sections shall be separated by oiled steel plates one-eighth inch thick set perpendicular to the face and top of curbing. Plates shall be shaped to the full cross section of the concrete and shall be allowed to remain in place until the concrete has set sufficiently to hold its shape, but shall be removed while the forms are still in place.

Expansion joints shall be formed in curbs and gutters at intervals of thirty feet, using premolded filler one-half inch in thickness cut to the required shape. When a curb is placed next to a concrete pavement, expansion joints in the curb shall be located opposite expansion joints in the pavement. Expansion joints shall be vertical and set at right angles to the curb and gutter.

58.7 Mixing and Placing Concrete. Subgrade and forms shall be checked and approved by the engineer and both subgrade and forms shall be thoroughly watered in advance of placing concrete. Concrete shall be Class A concrete proportioned and mixed as specified in Section 45. It shall be deposited in layers not exceeding four inches in thickness and each layer shall be thoroughly compacted and spaded away from the forms to eliminate stone pockets and bring mortar to the surface. The top of the curb and gutter shall then be floated smooth with a wooden float and the edges rounded to the radius shown on the plans. Combined concrete curb and gutter shall be placed in one operation and a construction joint shall not be allowed between curb and gutter. Before the concrete is given the final finishing, the surface of the gutter shall be checked with a

straightedge 10 feet long, and any irregularities of more than one-quarter inch in ten feet shall be eliminated.

58.8 Finishing. Forms shall be removed within 24 hours after the concrete has been placed. Minor defects shall be filled with mortar composed of one part cement and three parts fine aggregate. Plastering will not be permitted on any face of a curb or gutter. While still green, the face and top of the curb shall be trowelled smooth with a steel trowel and then brushed with a medium bristle brush to produce a lightly sanded surface. The gutter shall be finished by wetting a cement mortar brick or wood block and rubbing the surface until it is smooth and has a uniform color and texture. Sufficient water shall be used during finishing to keep the portion being rubbed moist. Edges of gutter and expansion joints shall be finished with an approved edging tool.

Faces of the finished curb and gutter shall be true and straight and of uniform width, free from humps, sags, or other irregularities and uniform in color. Any unacceptable portions shall be removed between joints and replaced without additional compensation.

58.9 Curing. As soon as the curb and gutter has been finished and is sufficiently hard to prevent marring, it shall be protected against rapid drying by covering with thoroughly wet absorbent mats wider than the width of the curb and gutter and laid directly on the surface. The mats shall be kept in place for a period of seven days, or after one day the mats may be removed and earth substituted for the curing. The mats or earth shall be kept continuously wet during the curing period. Alternate wetting and drying shall not be permitted.

When required by the special provisions or approved in writing by the engineer, curb and gutter may be cured by means of an approved impervious membrane.

The membrane shall consist of a practically colorless impervious liquid of a type approved by the engineer. Any membrane material which would alter the natural color of the curb and gutter will not be permitted.

58.10 Backfilling. When curing is completed, curb and gutter shall be backfilled, as indicated on the plans, with

approved material thoroughly compacted with rollers or iron tamping tools. If so ordered by the engineer, backfill material shall be placed in layers.

58.11 Method of Measurement. The quantity to be paid for shall be the number of cubic yards of concrete in the curb and gutter, complete in place and accepted. In computing concrete yardage for payment, the dimensions used shall be those shown on the plans or ordered by the engineer.

58.12 Basis of Payment. The quantity, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Class A Concrete Curb and Gutter," which price shall be full compensation for concrete, expansion joint filler, preparing the subgrade, forms, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

Reinforcing steel, if required, shall be measured and paid for as specified in Section 46.

Excavation shall be measured and paid for as roadway excavation, Section 14, except that no payment shall be made for material removed outside vertical planes 12 inches from the neat lines of the curb and gutter and parallel thereto.

Backfill made with material excavated in preparing the subgrade shall not be paid for directly, and compensation therefor shall be included in the contract price for the curb and gutter. When backfill consisting of material other than roadway excavation is specified, it shall be paid for at the contract unit price for the material required.

When a layer of porous material is required under the curb and gutter, it shall be paid for at the contract unit price for the material specified.

SECTION 59—GROUTED RUBBLE GUTTER

59.1 Description. This item shall consist of a grouted rubble gutter constructed at points and to the dimensions indicated on the plans or ordered by the engineer, and in conformity with these specifications.

59.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Stone for masonry.....	Section 78
Mortar sand	Section 83
Portland cement	Section 89

59.3 Construction Details. A foundation shall be excavated to the required depth below and parallel with the finished surface of the gutter. All soft and yielding or other unsuitable material shall be removed and suitable material substituted. The foundation shall be thoroughly compacted and finished to a smooth, firm surface. When the character of the subgrade material is such that it will not afford a firm, true bearing for the gutter, the foundation shall be excavated below grade and the subgrade constructed with an approved porous material.

Gutter stones shall be bedded into the foundation in straight rows with each stone perpendicular to the finished surface. The stones shall be set in close contact, their flat surfaces up and the longest dimension at right angles to the center line of the gutter. They shall break joints satisfactorily, and there shall be no intervening spaces exceeding one inch in width. The stones shall be rammed thoroughly until the surface is firm and conforms to the finished surface in grade, alignment, and cross section. Any gutter having an irregular or uneven surface shall be taken up and relaid in a satisfactory manner.

After the stone has been rammed into place and the surface is satisfactory, the spaces or voids between and around the stones shall be filled with approved gravel, sand, or crushed stone, to within four inches of the surface, after which grout composed of one part Portland cement to three parts sand shall be poured and broomed into the spaces

between the stones, this operation being continuous until the grout remains about one-half inch below the tops of the stones. The grout shall be of such consistency that it will flow readily into the spaces between the stones, but it shall not be so wet that the solid matter separates from the water. After completion, the gutter shall be kept continuously wet for a period of not less than three days.

59.4 Method of Measurement. The quantity to be paid for shall be the number of square yards, measured in horizontal projection, of grouted gutter in place in the completed and accepted work. In computing the quantity for payment, the dimensions used shall not exceed those shown on the plans or ordered by the engineer.

59.5 Basis of Payment. The quantity, measured as provided above, shall be paid for at the contract unit price per square yard for "Grouted Rubble Gutter," which price shall be full compensation for the gutter, preparing sub-grade, backfilling when required, material for filling the intervening spaces, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 60—CONCRETE SIDEWALK

60.1 Description. This item shall consist of concrete sidewalk, constructed with Class A concrete in accordance with these specifications, at the locations and of the design and dimensions shown on the plans or ordered by the engineer.

60.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Coarse aggregate for Portland cement concrete.....	Section 76
Fine aggregate for Portland cement concrete.....	Section 81
Portland cement	Section 89
Bar reinforcement.....	Section 92
Premolded expansion joint filler.....	Section 105

60.3 Subgrade. Prior to placing sidewalk, a satisfactory subgrade shall be prepared true to lines and grades established by the engineer. It shall be thoroughly watered and compacted by rolling and tamping until hard and smooth. All soft and unsuitable material shall be removed and replaced with suitable material. When indicated on the plans or ordered by the engineer, a layer of approved, thoroughly compacted porous material shall be placed under the sidewalk.

60.4 Forms. Forms shall be of metal or wood, straight and free from warp, and of sufficient strength to resist springing during the placing of concrete. Timber forms, if used, shall be surfaced on the top edge and on the face next to the concrete and shall be not less than one and five-eighths inches thick after surfacing. Forms shall have a width equal to the full depth of the finished sidewalk. They shall be set with the upper edge true to line and grade and shall be held rigidly in place by stakes placed on the outside of the forms and set flush with the top edge of the form. All forms shall be thoroughly cleaned and oiled before placing concrete.

Side forms shall not be removed in less than 12 hours after finishing has been completed.

60.5 Mixing and Placing of Concrete. Subgrade and forms shall be checked and approved by the engineer before any concrete is placed. Concrete shall be Class A concrete, proportioned and mixed as specified in Section 45. It shall be deposited between the forms upon the wetted subgrade and shall then be leveled off and tamped sufficiently to eliminate voids and bring the mortar to the surface. It shall be floated smooth with a wooden float and the edges and both sides of expansion joints rounded to the radius shown on the plans. The surface shall be finished with a fine-hair push-broom drawn over the surface transverse to the line of traffic. Water, if necessary, shall be applied to the surface immediately in advance of the brooming. The surface shall be checked with a straightedge 10 feet long and any irregularities of more than one-quarter inch in 10 feet shall be eliminated. The sidewalk shall be blocked into squares as shown on the plans or ordered by the engineer.

60.6 Expansion Joints. Transverse expansion joints shall be formed in sidewalks at intervals of thirty feet, using premolded filler one-half inch in thickness cut to required shape. When the sidewalk is adjacent to a curb, the expansion joints in the walk shall match those in the curb. Expansion joints shall be vertical and at right angles to the face of the sidewalk.

60.7 Curing. As soon as the sidewalk has been finished and is sufficiently hard to prevent marring, it shall be protected against rapid drying by covering with thoroughly wet absorbent mats slightly wider than the width of the sidewalk and laid directly on the surface.

The covering shall be kept saturated until removed. The mats shall be kept in place for a period of seven days, or after one day, the mats may be removed and earth substituted for the curing. The mats and earth shall be kept moist during the curing period.

When curing is complete, the sidewalk shall be cleaned and the shoulders constructed to the final elevation and cross section.

When required by the special provisions or approved in writing by the engineer, sidewalks may be cured by means of an approved impervious membrane.

The membrane shall consist of a practically colorless impervious liquid of a type approved by the engineer. Any membrane material which would alter the natural color of the sidewalk will not be permitted.

60.8 Method of Measurement. The quantity to be paid for shall be the number of cubic yards of concrete in the sidewalk, complete in place and accepted. In computing the concrete yardage for payment, the dimensions used shall be those shown on the plans or ordered by the engineer.

60.9 Basis of Payment. The quantity, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Class A concrete, Sidewalk," which price shall be full compensation for the concrete, expansion joint filler, preparing the subgrade, forms, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

Reinforcing steel, if required, shall be measured and paid for as specified in Section 46.

Excavation shall be measured and paid for as roadway excavation, Section 14, except that no payment shall be made for materials removed outside vertical planes 12 inches from the neat lines of the sidewalk and parallel thereto.

Shoulders made with material excavated in preparing the subgrade shall not be paid for directly, and compensation therefor shall be included in the contract price for the sidewalk. When shoulders consisting of material other than roadway excavation are specified, they shall be paid for at the contract unit price for the material required.

When a layer of porous material is required under the sidewalk, it shall be paid for at the contract unit price for material specified.

SECTION 61—CATCH BASINS, INLETS, AND MANHOLES

61.1 Description. This item shall consist of the construction of catch basins, inlets, or manholes of Portland cement concrete, together with the necessary drains, grates, or covers at points and of the designs shown on the plans and in conformity with these specifications.

61.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Coarse aggregate for Portland cement concrete	Section 76
Fine aggregate for Portland cement concrete	Section 81
Portland cement	Section 89
Structural, rivet, and eyebar steel	Section 90
Gray iron castings	Section 91

61.3 Construction Details. Catch basins, inlets, and manholes shall be constructed in accordance with all of the requirements of Section 45. Inlet and outlet pipes shall be placed prior to pouring concrete.

Grates shall be set in full mortar beds or otherwise secured as shown on the plans. Mortar for setting grates shall be mixed in the proportions of one part cement to three parts of fine aggregate. Grates shall be set accurately to the final elevation so that no subsequent adjustments will be necessary. Concrete covers, when indicated on the plans, shall be constructed in such manner that they will fit snugly and be readily removable.

61.4 Method of Measurement. Grates of either cast iron or structural steel, as indicated on the plans, shall be measured in pounds. The weight of castings shall be computed from the dimensions shown on the approved shop drawings, assuming the cast iron to weigh 450 pounds per cubic foot, with an allowance of 10 percent for fillets and overrun. The weight of structural steel grates shall be computed from the dimensions shown on the approved shop drawings, in accordance with Section 47.

61.5 Basis of Payment. Concrete shall be measured and paid for as specified in Section 45.

Reinforcing steel shall be measured and paid for as specified in Section 46.

Grates, measured as provided above, shall be paid for at the contract unit price per pound for "Castings" or "Structural Steel," as the case may be, which price shall be full compensation for furnishing, fabricating, and installing grates, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

Necessary excavation shall be measured and paid for in accordance with Section 20.

Backfill shall be measured and paid for in accordance with Section 21.

Inlet and outlet pipes shall be measured and paid for in accordance with the specifications for the particular type of pipe required.

SECTION 62—BITUMINOUS TREATED FOOTPATHS

62.1 Description. This item shall consist of a bituminous footpath constructed in accordance with these specifications at points and of the design and dimensions shown on the plans or ordered by the engineer.

62.2 Materials. All materials shall conform to the requirements for the several items which constitute the footpath.

62.3 Construction Methods. The area for the footpath shall be graded to the lines and grades indicated on the plans or ordered by the engineer in accordance with the applicable portions of Sections 11 to 19, inclusive, and Section 23. Prior to placing the footpath, a satisfactory subgrade shall be prepared true to lines and grades established by the engineer. It shall be thoroughly watered and compacted by rolling and tamping until hard and smooth. All soft and unsuitable material shall be removed and replaced with suitable material.

Side forms consisting of two inch by four inch select merchantable grade Douglas fir or select merchantable grade Port Orford cedar shall be carefully placed to a full and firm bearing before the footpath is constructed. Forms shall be secured by nailing to two inch by four inch by two foot stakes.

Base and surface courses shall be constructed in accordance with the specifications for the particular items required.

Subgrade and base and surface courses shall be rolled until thoroughly compacted with a roller providing a compression of not less than 200 pounds per linear inch of roller width. Portions of the subgrade disturbed in the process of setting side forms shall be recompacted.

The completed footpath shall be true to lines, grades, and cross sections, and the surface shall be smooth, hard, and compact.

62.4 Method of Measurement. When the proposal contains such an item, the quantity to be paid for shall be the number of square yards of footpath complete in place in the accepted work, measured between the side forms.

When the proposal does not contain such an item, the quantities of the various items which constitute the completed and accepted footpath shall be measured for payment according to the plans and specifications for the several pay items and in terms of the units provided for such items.

62.5 Basis of Payment. When the proposal contains such an item, the quantity, measured as provided above, shall be paid for at the contract unit price per square yard for "Bituminous Footpath," which price shall be full compensation for preparing the subgrade, furnishing and installing side forms, placing base and surface courses, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work, except that excavation, borrow, select borrow, and overhaul shall be paid for as prescribed for those items.

When the proposal does not contain such an item, the quantities, measured as provided above, shall be paid for at the contract unit prices for the several pay items constituting the footpath and listed in the proposal, which prices shall be full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 63—PRESERVATIVE TREATMENTS FOR TIMBER

63.1 Description. This item shall consist of the treatment of Douglas fir timber, when required, with creosote, creosote petroleum, or creosote-coal tar preservative in conformity with these specifications.

63.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific reference to Part III is as follows:

Timber preservative.....Section 102

63.3 Air Seasoning. Materials to be treated, preferably, shall be air-seasoned until the moisture remaining in the wood will not prevent the injection and proper distribution of the specified amount of preservative. For air-seasoning, the materials shall be stored as follows: Lumber shall be segregated according to size, and each layer in the pile shall be separated by at least one-inch strips with an air space of one inch or more between each two pieces of lumber in any layer; for caps, stringers, posts, or large timbers, at least two-inch strips shall be used to separate the layers. Alleys at least three feet wide shall be left between rows of stacks, and the material shall be at least 12 inches off the ground on concrete or treated timber sills. Timber piles shall be stored in like manner, placing as nearly as practical only one length in a stack, using at least two-inch strips or saplings of equal size between each layer, and reversing all sticks in every other layer in order to keep the stack level. The space under and between the rows of stacks shall be kept free at all times of rotting wood, weeds, or rubbish. The yard shall be so drained that no water can stand under the stacks or in their immediate vicinity.

63.4 Oil Seasoning for Douglas Fir. Douglas fir may be seasoned by boiling in oil under a vacuum until the moisture remaining in the wood will not prevent the injection and proper distribution of the specified amount of preservative.

The material shall be boiled in creosote under a vacuum at temperatures which do not exceed 220° F. for piling and

200° F. for sawed timber and lumber. A minimum vacuum of 20 inches shall be maintained during boiling. The seasoning period shall be maintained until condensation passing off from the timber is at the rate of approximately one-tenth of a pound per cubic foot of timber per hour.

63.5 Preparation for Treatment. Each cylinder charge shall consist of pieces approximately equal in size and moisture and sapwood content, into which approximately equal quantities of preserving fluid can be injected. Pieces shall be so separated as to insure contact of steam and preservative with all surfaces.

63.6 Plant Equipment. Treating plants shall be equipped with the thermometers and gauges necessary to indicate and record accurately the conditions at all stages of treatment, and all equipment shall be maintained in a condition satisfactory to the engineer. The apparatus and chemicals necessary for making the analyses and tests required by the engineer shall also be provided by plant operators, and kept in condition for use at all times.

63.7 Penetration. The range of pressure, temperature, and time duration shall be controlled so as to result in a maximum penetration by the quantity of preservative injected. The vacuum requirements stipulated are in inches of mercury at sea level, and necessary corrections shall be made for altitude.

In Douglas fir the minimum penetration for the specified amount of creosote oil shall be as follows:

	SPECIFIED AMOUNT OF CREOSOTE			
	PER CUBIC FOOT			
	10 lbs. inch	12 lbs. inch	14 lbs. inch	16 lbs. inch
Piling	5/8	3/4	7/8	1
Timbers 12 inches by 12 inches and larger	0.65	0.75	0.85	1.00

For timbers less than 12 inches by 12 inches the required depth of penetration shall be determined by the formula:

$$P = Ps \frac{R}{Rs}$$

where P = required penetration.

Ps = specified penetration for 12-inch by 12-inch timbers.

R = ratio of the volume of the piece in question to its superficial area.

Rs = ratio of the volume of a 12-inch by 12-inch timber to its superficial area.

The penetration of the preservative shall be based on black or dark oil, and in no case will light discoloration of the wood, due to treatment, be taken into consideration in measuring the depth of penetration.

Tests for penetration shall be made by taking borings with an increment borer, or a five-eighths inch auger, all holes so bored to be plugged by the contractor with tight-fitting creosoted plugs.

As many penetration tests of lumber and piling shall be made as is considered necessary by the inspector. In the case of piling, the holes shall be bored midway between the ends.

In the case of timber and lumber, every fourth stick of the charge may be bored.

63.8 Quantity of Preservative. The amount of preservative to be used shall be as shown on the plans or specified, and this amount shall be retained in the timber unless the oil has been injected to refusal. Unless otherwise specified, preservative shall be grade one creosote oil and the amount of preservative retained shall be as follows:

Creosote or Creosote-Coal Tar—

For piles and timber in general road and bridge construction:

Full-cell process, not less than 12 pounds of oil per cubic foot of timber, or

Empty-cell process, not less than eight pounds of oil per cubic foot of timber.

63.9 Pressure Treatments for Douglas Fir. The following pressure processes shall be used for oil treatment of Douglas fir:

HEATING WITH OIL. It is not required that air-seasoned or kiln-dried Douglas fir be boiled under a vacuum, but it

may be desirable to hold the material in a creosote bath maintained at a temperature of 180° to 190° F. for a length of time which, combined with the pressure period, is, in the judgment of the operator, necessary to secure the specified absorption.

(a) FULL-CELL PROCESS. Following the heating period, in the case of air-seasoned material, and the period of seasoning under vacuum in the case of material artificially seasoned, the cylinder shall be filled with creosote and pressure applied, as required, to a maximum limit of 175 pounds per square inch and maintained, taking into consideration the quantity of creosote absorbed during the bath, until the specified absorption of creosote has been obtained.

Temperature of the creosote during the pressure period shall be as high as possible, with a minimum limit of 160° F. and a maximum limit of 200° F.

After pressure is completed, the cylinder shall be emptied of creosote and a vacuum of at least 20 inches promptly created and maintained for a sufficient period of time to free the material of dripping creosote.

(b) EMPTY-CELL PROCESS WITH INITIAL AIR. Following the heating period, in the case of air-seasoned material, and the period of seasoning under vacuum in the case of material artificially seasoned, the material shall be subjected to air pressure of an intensity and duration which, in the judgment of the operator, is sufficient to secure the final retention of the specified quantity of creosote.

The preservative shall then be introduced, the air pressure being maintained constant, until the cylinder is completely filled.

Creosote shall then be pressed from the measuring tanks into the wood in a quantity which, in the opinion of the operator, is sufficient to leave the required retention at the completion of the process herein described. Maximum pressure shall in no case exceed 200 pounds per square inch. The temperature of the creosote during the pressure period shall be as high as possible, with a minimum limit of 160° F. and a maximum limit of 200° F.

After pressure is completed, the cylinder shall be quickly emptied of creosote and a vacuum of at least 20 inches promptly created and maintained for such a period of time

as may be required to remove dripping creosote from the material.

63.10 Open-Tank Treatments. Open-tank treatment shall consist of a hot bath treatment or a hot and cold bath treatment as may be specified.

All tanks used in the open tank process shall be of sufficient size to allow free circulation of the liquid around the largest amount of timber being treated in any operation.

Sufficient liquid shall be maintained in the tanks to completely immerse the timber. When a number of pieces are being treated at each operation, each stick shall be separated from the others on all sides by square or round spacers not less than one-quarter inch in least dimension. Suitable slings and handling devices shall be provided for the transfer of material necessary during the complete process without disturbing the stacked position of the pieces in the bundle.

For hot bath treatments at least one tank shall be supplied having suitable steam coils or other heating device to keep the liquid at a uniform temperature of not less than 240° F. throughout the tank during the complete process.

For hot and cold bath treatments at least one hot tank shall be supplied as for the hot bath treatment and one cold tank having the same capacity as the hot tank. The cold tank shall be equipped with suitable cold water coils or water jackets, so that the temperature of the liquid at the time of immersion of each batch of timber shall be no higher than the surrounding atmospheric temperature.

All timber to be treated shall be free from dirt, grease, or other foreign matter which will in any way hinder the free penetration of the preservative. Framing shall be done before treatment. Round timber or timber with wane shall have the rough bark and inner bark removed as specified for wood piling in Section 101.

(a) **SINGLE OR HOT BATH TREATMENT.** The timber shall be completely immersed in preservative in the hot tank, which shall be maintained at a temperature of 190° F. for seasoned timber and 230° F. for timber not seasoned. A tolerance of 10° in either direction is permissible. For seasoned timber the immersion shall be for a period of not less than 25 minutes for two-inch timber with an increase of eight minutes in the immersion period for each additional

inch in thickness. For unseasoned timber, the immersion period shall be doubled.

(b) HOT AND COLD TREATMENT. The timber shall be completely immersed in preservative in the hot tank, which shall be maintained at a temperature of 190° F. for seasoned timber and 230° F. for timber not seasoned. A tolerance of 10° in either direction is permissible. For seasoned timber the immersion shall be for a period of not less than 25 minutes for two-inch timber with an increase of eight minutes in the immersion period for each additional inch in thickness. For unseasoned timber the immersion period shall be doubled. At the end of this period the timber shall be removed from the hot tank and immediately immersed in the cold tank. At the time of transfer the preservative in the cold tank shall have a temperature as low as possible, but in no case higher than the surrounding air temperature. The timber shall be completely immersed in the cold tank for a period one half as long as for the hot bath.

Successive charges from the hot tank may be placed first in one cold tank and the next in a second cold tank in order to keep the cold tank temperature as low as possible at the time of immersion. Should the contractor supply a cold tank capable of handling all material and with a cooling system which will secure the specified temperature at the time of all cold treatment as specified, only one cold tank may be required. Single cold tank equipment shall be subject to the approval of the engineer.

63.11 Brush Treatment. All timber to be given brush treatment shall be free from atmospheric moisture, and in no case shall brush treatment be applied when the surface of the timber is wet. The surfaces to be treated shall be free from dirt, grease, or other foreign matter which will in any way hinder the maximum penetration of the preservative.

The preservative shall be heated in proper receptacles immediately adjacent to the point of application and shall be applied within the temperature range of 170° to 190° F. for seasoned wood and 220° to 240° F. for unseasoned wood.

A minimum of two coats shall be applied to all surfaces to be treated except cut ends, joints, and mortises, which

shall be given three coats. Each coat shall be allowed to penetrate before applying the next coat. All checks, bolt holes, and cracks shall be run full of the preservative oil and an extra heavy treatment shall be given to knotty spots.

63.12 Spray Treatment. The condition of the timber prior to spray treatment shall conform to the requirements specified for brush treatment.

The temperature of the preservative shall be maintained at 240° F. The shortest length of hose practicable shall be used to prevent undue chilling between the spray tank and nozzle. Preservative shall be renewed frequently in the spray tank to prevent chilling. The spray shall be applied with a good pressure and only fine enough to prevent waste, until the preservative begins to run. Equipment employing air pressure which has a cooling effect on the hot preservative shall not be used.

Two liberal applications shall be made, allowing sufficient time for the absorption of the first application before the second is made.

63.13 Measurement and Payment. Payment shall be made in accordance with the specifications for the particular item of work into which the treated timber enters.

SECTION 64—GUARD RAIL

64.1 Description. This item shall consist of furnishing all materials and erecting a metal plate guard rail, conforming to the plans and these specifications, at points and to the lines and grades shown on the plans or ordered by the engineer.

64.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Treated Douglas fir guard rail	
posts (1100#c)	Section 100
Redwood guard rail posts	
(1100#c close-grained)	Section 100
Port Orford cedar guard rail	
posts (1100#c)	Section 100
Timber preservatives	Section 102
Guard rail materials	Section 104
Paints and paint materials	Section 106

64.3 Construction Details. Unless otherwise specified, metal guard rail may be constructed with either redwood, Port Orford cedar, or treated Douglas fir posts, and floating, nonfloating or beam type plates, springs, and fittings at the option of the contractor. Douglas fir posts shall be given a preservative treatment from the bottom to a point two inches above ground line, by the open tank or brush methods, as specified in Section 63. Post spacing shall be as shown on the plans.

Posts shall be set plumb, except on superelevated curves where they shall be set perpendicular to the roadbed. Front faces of posts shall form a straight line, except on curves where they shall be a uniform distance from the center line of the roadway. Post holes shall be backfilled in layers with approved material thoroughly rammed with an iron tamping tool in such manner as not to displace the bottoms of posts from correct alignment. All surfaces of the posts in contact with fittings shall receive one coat of the prescribed paint before the fittings are placed.

The rail shall be erected in the manner shown on the plans. Workmanship shall be first class in all respects and

framing shall be done and fittings attached in such manner that the rail, after erection, shall be true to line and grade and shall have the proper tension in the rail plates. Care shall be taken to prevent the disturbance of posts during the erection of the rail, and, when necessary, temporary braces shall be installed to insure against post displacement.

Nonfloating and floating type rails shall be erected so that all slack is eliminated, and the resilient details or springs are only partially taken up in tension. The tension shall be uniform throughout the length of the rail. Where slotted holes are used for movement of rail elements, the brackets shall be adjusted so that when the rail is under proper tension the bolts are in the middle of the slotted holes. Beam type rails shall be erected so that the bolts at expansion joints are located at the centers of the slotted holes.

The maximum length between anchorages shall not exceed 500 feet nor one-half the radius if the rail is on a curve. In any length of rail, the anchorages shall divide the length into approximately equal divisions. Intermediate anchorages shall be constructed to result in a continuous, resilient rail with an overlapping expansion joint at each intermediate anchorage. Anchorages, springs, and take-ups, as required by the rail type used, equivalent to those at the end of the rail, shall be provided each side of each expansion joint. Floating take-ups will not be permitted.

After erection, posts and all metal parts and fittings, free from coatings of any kind including dirt, rust, and oil and grease, shall be given three coats of paint as specified in Section 66, except that the prescribed priming coat shall be omitted on all metal parts and fittings which have been galvanized, but such parts, prior to applying paint, shall be slightly etched with a solution composed of one quart of vinegar to two gallons of water. The surface shall be rinsed with clear water and allowed to dry thoroughly before painting.

After the rail has been painted as specified, nuts fastening rail plate to springs shall be backed off slightly so that the connection is firm but not tight and will permit the

slight movement necessary to absorb expansion and contraction of the rail.

64.4 Method of Measurement. The quantity to be paid for shall be the number of linear feet of rail, complete in place and accepted, measured along the front face of the rail between centers of end posts.

64.5 Basis of Payment. The quantity, measured as provided above, shall be paid for at the contract unit price per linear foot for "Metal Guard Rail" when type is optional, or at the contract unit price per linear foot for "Nonfloating Type Metal Guard Rail," "Floating Type Metal Guard Rail," or "Beam Type Metal Guard Rail," as the case may be, when type is specified, which price shall be full compensation for furnishing all materials, treating posts, inspection certificates, excavating and backfilling post holes, erecting the rail, painting, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 65—CULVERT MARKERS AND GUIDE POSTS

65.1 Description. This item shall consist of furnishing all materials and erecting timber posts for culvert markers or guide posts, conforming to these specifications, at points shown on the plans or ordered by the engineer.

65.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Timber posts, Douglas fir, select merchantable plank	Section 100
Timber posts, Port Orford cedar, dense select merchantable plank....	Section 100
Paints and paint materials.....	Section 106

65.3 Construction Methods. Unless otherwise specified, culvert markers and guide posts may be either Douglas fir or Port Orford cedar. They shall be spaced and erected in the manner indicated on the plans, and shall be set plumb, except on superelevated curves where they shall be set perpendicular to the roadbed. Holes shall be back-filled in layers with approved material thoroughly rammed with an iron tamping tool.

After erection, and when the wood is dry and clean, posts shall be given three coats of paint and stenciled numbers and trim shall be applied as specified in Section 66. Posts shall be painted at least nine inches below ground.

65.4 Measurement and Payment. The number of culvert markers and guide posts in the completed and accepted work shall be paid for at the contract unit price each for "Culvert Markers" or "Guide Posts," as the case may be, which price shall be full compensation for furnishing, erecting and painting the posts, for inspection certificates, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work, including excavation and backfill.

SECTION 66—PAINTING

66.1 Description. This item shall consist of the preparation of surfaces to be painted and the application, protection, and drying of the required number of coats of paint of the kinds and at points specified or ordered by the engineer.

66.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific reference to Part III is as follows:

Paint and paint materials.....Section 106

66.3 Number of Coats. Unless otherwise required on the plans or in the special provisions, the number and kind of coats of paint shall be as follows:

Structural steel and metal parts—

First coat (shop)—Formula A

Second coat—Formula B

Third coat—Formula C, H, or I

Wood and timber—

First coat—Formula D or E

Second coat—Formula F or G

Third coat—Formula F, G, H, or I

Black trim—Formula J

66.4 Preparation of Surface. Surfaces to be painted shall be thoroughly cleaned before paint is applied. Rust, loose mill scale, dirt, oil or grease, and other foreign substances shall be removed from metal surfaces by the use of sand blasts, metal brushes, scrapers, chisels, hammers, or other effective means. Oil and grease shall be removed by the use of gasoline or benzine. Bristle brushes shall be used for removing loose dust. Timber surfaces shall be cleaned of dust, dirt, and other foreign matter by brushing or other effective means.

66.5 Application—General. Paint shall be applied only when the air temperature is at or above 40° F. It shall not be applied upon damp surfaces or surfaces containing frost, nor shall it be applied when the air is misty, or otherwise unsatisfactory for the work, in the opinion of the engineer.

Materials painted under cover in damp or cold weather

shall remain under cover until dry, or until weather conditions permit its exposure in the open. Painting in open yards or upon erected structures shall not be done when the material has absorbed sufficient heat to cause the paint to blister and produce a porous paint film.

Paint shall be applied with brushes unless otherwise permitted in writing by the engineer. When permission is granted to employ paint spraying machines, it shall be upon the condition that the work done by them will be equivalent in all respects, in the opinion of the engineer, to that obtained with hand brushes, and should results obtained prove unsatisfactory, the use of the machines shall be immediately discontinued.

Paint shall be applied with round or oval brushes unless otherwise permitted in writing by the engineer. The paint when applied shall be so manipulated under the brush as to produce a uniform, even coating in close contact with the surface and shall be done in a neat, workmanlike manner. In general, the primary movement of the brush shall describe a series of small circles to fill thoroughly all irregularities in the surface, after which the coating shall be smoothed and thinned by a series of parallel strokes. Paint shall be evenly spread and thoroughly brushed out. The appearance of any considerable amount of brush marks shall be considered as evidence that the paint is not being brushed out sufficiently. On all surfaces which are inaccessible for brushing, the paint shall be applied by sheepskin daubers especially constructed for the purpose.

A mechanical paint mixer shall be used to stir the paint in the original containers prior to drawing the paint off into the painter's buckets. Mechanical agitation shall be continued sufficiently long to mix the pigment and vehicle thoroughly. Paint shall be kept thoroughly stirred while being applied to keep the pigments in suspension.

If it is necessary in cool weather to thin the paint in order that it will spread more freely, this shall be done only by heating the containers in hot water. No thinners shall be added except as provided in the paint formulas.

66.6 Protection. The contractor shall protect pedestrian, vehicular, or other traffic adjacent to all work being painted, and shall also protect all parts of the structure

or adjacent structures against disfigurement by spatters, splashes, and smirches of paint or paint materials. When necessary, canvas shields or other protective means shall be used to guard against such damage. Paint stains which result, in the opinion of the engineer, in an unsightly appearance shall be removed or satisfactorily obliterated.

The contractor shall furnish and erect such signs as the engineer may deem necessary to control the speed of traffic and give warning of the painting operations. When traffic causes an objectionable amount of dust, the contractor shall sprinkle the adjacent roadway sufficiently to eliminate this condition.

66.7 Shop Painting Steel. Surfaces to be riveted in contact, either in the shop or field, shall not be painted, but such surfaces shall be thoroughly cleaned of rust, mill scale, dirt, grease, or other foreign matter at the time of bolting up and riveting. Surfaces not in contact but which will be inaccessible after assembly or erection shall receive two coats of the specified shop paint.

When fabrication is complete and the work has been accepted, surfaces not painted before assembling, except surfaces to be in contact after erection, shall be painted one coat of the specified shop paint. Material shall not be loaded for shipment until the paint is dry.

Erection marks shall be painted on painted surfaces.

With the exception of abutting chord and column splices and column and truss shoe bases, machine surfaces shall be coated as soon as practicable after being accepted, and before removal from the shop, with a hot application of lead and tallow.

Surfaces of iron and steel castings which have been machine finished in order to remove scales, scabs, fins, blisters, or other surface deformities shall be painted with one coat of shop paint.

66.8 Field Painting Steel. As soon as the field cleaning has been satisfactorily completed, the heads of field rivets and bolts, and any surfaces from which the shop coat of paint has been worn off or has become otherwise defective, shall be covered with one coat of the same paint as was used in the shop.

Small cracks and cavities which have not been sealed in a water-tight manner by the first field coat shall be filled with red lead paste before the second field coat is applied.

When the paint applied for touching up rivet heads and abraded surfaces has become dry, the first field coat may be applied. In no case shall a coat be applied until the previous coat has dried throughout the full thickness of the paint film.

To secure a maximum thickness of paint film on rivet heads and edges of plates, angles, and other rolled shapes, these parts shall be painted an extra coat in advance of the general application of each field coat.

66.9 Painting Timber. After the priming coat has dried, all cracks and openings in the timber and surfaces that are checked shall be puttied. Succeeding coats of paint shall not be applied until at least three days after the preceding coat has hardened enough to prevent breaking under the brush.

66.10 Measurement and Payment. No direct payment shall be made for painting. Compensation for this work shall be considered as included in the contract prices for the particular item requiring painting.

SECTION 67—FENCING

67.1 Description. This item shall consist of furnishing all materials and erecting new fences, or reconstructing fences previously removed, in conformity with these specifications and of the types and at points shown on the plans or ordered by the engineer.

67.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific reference to Part III is as follows:

Fence posts and fence materials....Section 103

67.3 Construction Methods. All clearing which would interfere with proper construction shall be done in advance of constructing the fence. Material so removed shall be disposed of in accordance with the requirements of Section 11. Fences shall be constructed on the highway right of way line unless otherwise specified. Posts shall be firmly set into the ground and spaced as indicated on the plans. Each end, corner, and gate post shall be firmly braced and shall be set in concrete when required. When wood posts are used, each gate, end, and corner post shall be spaced at one-half the regular interval from the adjacent line post. Posts shall be braced as indicated on the plans. Brace posts shall be placed in the fence line at intervals of not more than 660 feet unless a gate intervenes, or as shown on the plans.

The wire shall be stretched taut without warping and securely fastened to each post with one and three-quarters inch galvanized staples or approved galvanized wire ties. Gates shall be installed at points indicated on the plans or directed by the engineer.

At all grade depressions and alignment angles, where stresses tending to pull the posts from the ground are created, the fencing shall be snubbed or guyed at the critical point by means of a double strand of 6-gage wire connected to each horizontal line of fence wire and to a deadman weighing approximately 100 pounds buried in the ground not less than two feet. The fencing shall be pulled snug to the ground before being snubbed or guyed.

Reconstructed fences shall be carefully erected, using salvaged materials, and shall be similar in type to the original construction. Any new materials necessary to rebuild the fence shall be furnished by the contractor, shall be of the same kind as those in the original fence, and the cost thereof shall be included in the contract price for the work. The resulting reconstructed fence shall be equal to or better than before removing. In reconstructed fences, the department reserves the right to furnish the contractor with such new materials as it deems advisable, and these materials shall be used in the reconstruction of the fence in lieu of the salvaged materials which they replace.

The finished fence shall be true to line, with tops of posts cut square and paralleling the general contour of the ground, and the whole shall be taut and solid at all points.

All fences which are the property of the department shall be set with the wire six inches inside of the right of way line, and with posts on the highway side of wire.

Fences which are the property of a private owner shall be set directly on the right of way line.

67.4 Method of Measurement. The quantity of new fencing to be paid for shall be the number of linear feet of fence, exclusive of gates and cattle guards, measured in the completed and accepted work.

The quantity of reconstructed fencing to be paid for shall be the number of linear feet of fence, including gates, measured in place in the completed and accepted work, except that when new gates are required, the length of such gates shall be excluded.

The number of new gates installed in the completed and accepted work shall be measured as units.

67.5 Basis of Payment. The quantity of new fence constructed, or fence reconstructed, measured as provided above, shall be paid for at the contract unit price per linear foot for "Construct Fence" or "Reconstruct Fence," as the case may be.

The number of new gates installed, measured as provided above, shall be paid for at the contract unit price each for "..... ft. Gates."

Payment provided above shall be full compensation for furnishing and installing fences and gates, including clearing, excavating, backfill, and concrete, and for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

SECTION 68—MONUMENTS

68.1 Description. This item shall consist of furnishing and erection of Portland cement concrete monuments of the design and at the locations indicated on the plans or directed by the engineer.

68.2 Materials. All materials shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Water	Section 70
Coarse aggregate for Portland cement concrete.....	Section 76
Fine aggregate for Portland cement concrete.....	Section 81
Portland cement	Section 89
Bar reinforcement.....	Section 92

68.3 Construction Methods. Monuments shall be fabricated from Class D concrete in accordance with the specifications for Portland cement concrete, Section 45.

Suitable forms and methods shall be used for obtaining clean, sound, and uniform monuments conforming to the design and dimensions shown on the plans.

Monuments shall be set to define the right of way lines and, unless otherwise specified, shall be set at the beginning and end of each project, at the beginning and end of each curve, at all corners of irregular right of way lines, and approximately one mile apart on long tangents. Monuments shall be set in compacted soil exactly in accordance with the lines as staked by the engineer. The holes shall be backfilled with approved materials, in layers, thoroughly rammed with a steel tamping tool in such manner that the monument will not be displaced from its true position.

68.4 Method of Measurement and Basis of Payment. This work shall be paid for at the contract unit price each for "Monuments" complete in place, which price shall be full compensation for all labor, material, tools, supplies, equipment, and incidentals necessary to complete the work, including excavation and backfill.

SECTION 69—FIELD LABORATORY

69.1 Description. This item shall consist of furnishing all materials and erecting a field laboratory for the exclusive use of the engineer, in conformity with these specifications and of the design and dimensions shown on the plans.

69.2 Construction Details. When required herein or by the special provisions, the contractor shall erect a field laboratory. The building shall have a floor plan with the approximate dimensions shown on the plans, shall be located conveniently as directed by the engineer, and shall be independent of any building used by the contractor. It shall be constructed of wood or other approved material and shall be weathertight. The ceiling height shall be not less than eight feet and it shall have windows, doors, tables, lockers, and other equipment as shown on the plans or ordered by the engineer. If the work is prosecuted in cold weather, the contractor shall provide heat for the building.

Upon completion of the work, the building shall become the property of the contractor and he shall remove or otherwise dispose of it to the satisfaction of the engineer.

69.3 Method of Measurement and Basis of Payment. Unless such an item is included in the proposal, this work shall not be paid for directly and compensation for the construction of the laboratory shall be considered as included in the contract prices for other items of the work.

When such an item is included in the proposal, this work shall be paid for at the contract lump sum price for "Field Laboratory," which price shall be full compensation for all labor, materials, tools, supplies, equipment, and incidentals necessary to complete the work.

PART III

MATERIAL DETAILS

SECTION 70—WATER

70.1 Material Covered. This specification covers quality of water for use in concrete and application to the roadway.

70.2 Quality. All water used in concrete shall be subject to the engineer's approval, shall be reasonably clear and free of oil, acid, alkali, and vegetable substances, and shall not be brackish or salty. Water for embankments, subgrade, curing, and base and surfacing courses shall be reasonably free from alkali or other substances likely to cause damage to base and surfacing courses.

70.3 Tests. Water of doubtful quality for use in concrete shall be tested by comparison with distilled water. Comparison shall be made by standard tests for soundness, time of setting, and 1-3 mortar strength. Standard sand and the same grade of cement shall be used in all such tests. Any indication of unsoundness, marked change in time of setting, or reduction of more than 10 percent in strength from results obtained with mixtures containing distilled water shall be sufficient cause for rejection of the water that is being tested. Water which is suitable for drinking, or ordinary household use may be accepted for use without being tested.

70.4 Sampling Water for Testing. Care shall be taken that the containers are clean and that the samples are representative. Samples of water forwarded to the laboratory shall be shipped in glass containers.

SECTION 71—SELECTED MATERIAL

71.1 Material Covered. This specification covers the quality and size of selected material for base and surfacing.

71.2 General Requirements. Selected material shall consist of pit-run gravel, talus rock, disintegrated granite, other disintegrated rock, cinders, shale or other similar materials.

71.3 Physical Properties. The fraction passing the No. 40 sieve shall have a plasticity index of not more than six and a liquid limit of not more than 25. When the material is to be treated with liquid asphalt it shall be of such character that it will pass the stripping and swell tests.

71.4 Size Requirements. The material shall conform to the following sieve analysis:

Laboratory sieve, square openings	Percentage by weight passing sieve
2 inch	95-100
$\frac{3}{4}$ inch	85-100
No. 10	40-85
No. 40	15-50
No. 200	*0-25

*The fraction passing the No. 200 sieve shall be less than two-thirds of the fraction passing the No. 40 sieve.

71.5 Sampling and Testing. Sampling and testing of selected material shall be in accordance with the following methods:

Sampling	A.A.S.H.O. T-2
Portion passing 200 mesh	A.A.S.H.O. T-11
Size	A.A.S.H.O. T-27
Liquid limit	A.A.S.H.O. T-89
Plasticity index	A.A.S.H.O. T-91
Swell	Nevada Section 6
Stripping test	Nevada Section 6

SECTION 72—AGGREGATE FOR GRAVEL BASE COURSES

72.1 Material Covered. This specification covers the quality and size of pit-run gravel, screened gravel, crushed gravel, crushed stone, and filler for the following base courses:

- (a) Type 1 Gravel Base
- (b) Type 2 Gravel Base

72.2 General Requirements. The aggregate shall be the product of approved deposits and shall consist of hard, durable fragments of stone or gravel and a filler of sand or other finely divided mineral matter. It shall be free from an excess of soft or disintegrated pieces, alkali, and vegetable matter.

The minimum amount of crushed material in the finished product shall be as follows:

- (a) Type 1 Gravel Base—No requirements.
- (b) Type 2 Gravel Base—That obtainable by crushing and incorporating into the finished product all particles in the pit-run material larger than the maximum size specified for the finished product and less than six inches in largest dimension.

72.3 Physical Properties. The aggregate shall conform to the following requirements:

	Type 1 Gravel Base	Type 2 Gravel Base
Percentage of wear (L. A. Rattler 500 rev.), % max.....	---	45
Fraction passing No. 40 sieve— Plasticity index, max.....	6	6
Liquid limit, max.....	*25	25

*Type 1 Gravel Base having no plasticity index may have a liquid limit as high as 35.

72.4 Size Requirements, Type 1 Gravel Base. The aggregate shall conform to one of the following sieve analyses, the size selection to be optional with the contractor unless otherwise specified:

Laboratory sieve, square openings	PERCENTAGE BY WEIGHT PASSING SIEVE		
	Pit run	2-inch size	1½-inch size
3 inch			
2 inch	-----	95-100	
1½ inch	-----	-----	95-100
1 inch	45-80	50-85	55-95
No. 10	20-45	20-55	25-65
No. 200	0-15	0-18	0-20

NOTE—If the product of any deposit is deficient in the fraction passing the No. 10 sieve, additional filler from other approved deposits meeting the physical requirements shall be provided.

72.5 Size Requirements, Type 2 Gravel Base. The aggregate shall conform to one of the following sieve analyses, as specified:

Laboratory sieve, square openings	PERCENTAGE BY WEIGHT	
	PASSING SIEVE	
	1½-inch size	1-inch size
1½ inch	100	
1 inch	-----	100
¾ inch	60-80	80-100
No. 4	35-50	45-70
No. 10	25-40	35-50
No. 40	10-30	15-35
No. 200	*5-15	*5-12

*The fraction passing the No. 200 sieve shall be less than two-thirds of the fraction passing the No. 40 sieve.

NOTE—If the product of any deposit is deficient in the fraction passing the No. 10 sieve, additional filler from other approved deposits meeting the physical requirements shall be added at the crushing and screening plant.

72.6 Sampling and Testing. Sampling and testing of aggregate for gravel base courses shall be in accordance with the following standard test methods:

Sampling	A.A.S.H.O. T-2
Portion passing 200 mesh	A.A.S.H.O. T-11
Size	A.A.S.H.O. T-27
Liquid limit	A.A.S.H.O. T-89
Plasticity index	A.A.S.H.O. T-91
Percentage of wear	A.A.S.H.O. T-96

SECTION 73—AGGREGATE FOR ROADMIX AND PLANTMIX BITUMINOUS SURFACES

73.1 Material Covered. This specification covers the quality and size of crushed stone or crushed gravel and filler for the following bituminous surface courses:

- (a) Class B1 Roadmix Bituminous Surface.
- (b) Class C1 Roadmix Bituminous Surface.
- (c) Class F1 Plantmix Bituminous Surface.
- (d) Class F2 Plantmix Bituminous Surface.

73.2 General Requirements. The aggregate shall be the product of approved deposits and shall consist of hard, tough, durable fragments of stone or gravel and a filler of sand or other finely divided mineral matter free from an excess of flat, elongated, soft or disintegrated pieces, alkali, and vegetable matter. The material shall be of such character that it shall pass both the swell and stripping test when mixed with bituminous material.

The amount of crushed material shall be as follows for all classes:

That obtainable by crushing and incorporating into the finished product all particles in the pit-run material larger than the maximum size specified for the finished product and less than 6 inches in largest dimension.

73.3 Physical Properties. The aggregate shall conform to the following requirements:

Percentage of wear (L. A. Rattler, 500 revolutions) max. %	45
Fraction passing No. 40 sieve—	
Plasticity index, max.	6
Liquid limit, max.	25
Swell test, % max.	1.5
Stripping test	Satisfactory

73.4 Size Requirements. The aggregate shall conform to the following sieve analysis:

Laboratory sieve, square openings	Percentage by weight passing sieve
1 inch	100
$\frac{3}{4}$ inch	80-100
No. 4	45-70
No. 10	30-50
No. 40	15-35
No. 200	*5-12

*The fraction passing the No. 200 sieve shall be less than two-thirds of the fraction passing the No. 40 sieve.

NOTE—If the product of any deposit is deficient in the fraction passing the No. 10 sieve, additional filler from other approved deposits meeting the physical requirements shall be added at the crushing and screening plant.

73.5 Sampling and Testing. Sampling and testing of aggregate for gravel base courses shall be in accordance with the following methods:

Sampling	A.A.S.H.O. T-2
Portion passing 200 mesh.....	A.A.S.H.O. T-11
Size	A.A.S.H.O. T-27
Liquid limit	A.A.S.H.O. T-89
Plasticity index.....	A.A.S.H.O. T-91
Percentage of wear.....	A.A.S.H.O. T-96
Swell	Nevada Section 6
Stripping	Nevada Section 6

SECTION 74—CRUSHED ROCK AND SCREENINGS FOR ROAD TREATMENT WITH BITUMINOUS MATERIALS.

74.1 Materials Covered. This specification covers the quality and size of crushed rock and screenings for the following surface courses:

Class A1 Bituminous Surface Treatment.

Class A Bituminous Armor Coat.

Class C2 Retread Surface.

74.2 General Requirements. Coarse aggregate and key rock shall be the product obtained by crushing material from approved deposits of ledge rock or gravel. When crushed from gravel, coarse aggregate and key rock shall be the product of crushing particles retained on a screen with square openings not less than one and one-half times the nominal maximum size of the material produced.

Screenings may be either stone chips, the product of an approved gravel deposit, or a combination of stone chips and gravel.

All coarse aggregate, key rock, and screenings shall consist of clean, tough, durable fragments, free from an excess of flat, elongated, soft or disintegrated pieces, alkali and vegetable matter. Material shall be of such character that when mixed with bituminous materials it will pass the stripping test.

74.3 Physical Properties. The aggregate shall conform to the following requirements:

Percentage of wear:

L. A. Rattler, 100 rev., % max..... 8

L. A. Rattler, 500 rev., % max..... 37

Removed by decantation, % max..... 2

When subjected to five alternations of the sodium sulphate soundness test the loss shall not be more than 10 percent by weight.

74.4 Size Requirements, Bituminous Retread Surface. The aggregate shall conform to one of the following sieve analyses, as specified:

TYPE 1

Laboratory sieve, square openings	PERCENTAGE BY WEIGHT PASSING SIEVE	Coarse aggregate	Key rock	Screenings
2 inch	100			
1½ inch	95-100			
¾ inch	0-5	100		
½ inch	-----	95-100		100
⅜ inch	-----	-----		90-100
No. 4	-----	0-5		
No. 10	-----	-----		0-5

TYPE 2

Laboratory sieve, square openings	PERCENTAGE BY WEIGHT PASSING SIEVE	Coarse aggregate	Key rock	Screenings
1 inch	100			
¾ inch	95-100			
⅜ inch	20-55	100		100
½ inch	0-10	-----		95-100
No. 10	-----	0-10		0-5

74.5 Size Requirements, Bituminous Armor Coat. The aggregate shall conform to the following sieve analyses:

Laboratory sieve, square openings	PERCENTAGE BY WEIGHT PASSING SIEVE	Coarse aggregate	Key rock	Screenings
1 inch	100			
¾ inch	95-100	100		
½ inch	0-10	95-100		
⅜ inch	-----	-----		100
½ inch	-----	0-10		95-100
No. 10	0-5	0-5		0-5

74.6 Size Requirements, Screenings for Bituminous Surface Treatment. The aggregate shall conform to the following sieve analysis:

Laboratory sieve, square openings	Percentage by weight passing sieve
⅜ inch	100
½ inch	90-100
No. 10	0-8
No. 200	0-2

74.7 Sampling and Testing. Sampling and testing of aggregate for coarse aggregate, key rock and screenings shall be in accordance with the following standard test methods:

Sampling	A.A.S.H.O. T-2
Removal by decantation.....	A.A.S.H.O. T-11
Size	A.A.S.H.O. T-27
Soundness	A.A.S.H.O. T-104
Percentage of wear.....	A.A.S.H.O. T-96
Stripping.....	Nevada Section 6

SECTION 75—COARSE AGGREGATE FOR BITUMINOUS CONCRETE

75.1 Material Covered. This specification covers the quality and size of crushed rock or crushed gravel to be used in the construction of bituminous concrete. It covers the coarse aggregate for base, leveling, and top courses.

75.2 General Requirements. Coarse aggregate shall be the product obtained by crushing material from approved deposits of ledge rock or gravel. Crushed stone or crushed gravel shall consist of clean, tough, durable fragments, free from an excess of flat, elongated, soft or disintegrated pieces, and free from particles coated with other objectionable matter. The material shall be of such character that when coated with asphalt cement proposed for the work, it will pass the stripping test.

When crushed from gravel, coarse aggregate shall be the product of crushing particles, all of which are retained on a screen with two-inch square openings. Should the producer elect to utilize that material which passes the two-inch screen it shall be further scalped on a screen with three-quarter-inch openings. Material passing the two-inch screen and retained on the three-quarter-inch screen shall be crushed to such size that all will pass a screen with three-quarter-inch square openings. This product shall then be blended uniformly with corresponding sizes produced by crushing the particles of gravel larger than two inches.

75.3 Physical Properties. When tested by the methods specified below the material shall meet the following requirements:

Percentage of wear—

L. A. Rattler, 100 rev., % max.....	8
L. A. Rattler, 500 rev., % max.....	37

75.4 Size Requirements. When tested by means of laboratory sieves, coarse aggregate shall be well graded between the largest and the smallest sizes permissible, and the different courses also shall meet the grading requirements shown in the following table:

Laboratory sieve, square openings	—PERCENTAGE BY WEIGHT PASSING SIEVE—		
	Bottom course	Leveling course	Top course
2 inch	95-100		
1 inch	55-70	95-100	95-100
$\frac{1}{2}$ inch	30-45	35-55	35-55
No. 10	0-5	0-5	0-5

75.5 Sampling and Testing. Sampling and testing of the coarse aggregate shall be in accordance with the following standard test methods:

Sampling	A.A.S.H.O. T-2
Size	A.A.S.H.O. T-27
Percentage of wear	A.A.S.H.O. T-96
Stripping	Nevada Section 6

SECTION 76—COARSE AGGREGATE FOR PORTLAND CEMENT CONCRETE

76.1 Material Covered. This specification covers the quality and size of coarse aggregate for use in Portland cement concrete.

76.2 General Requirements. The coarse aggregate for Portland cement concrete shall consist of crushed stone, gravel, or other approved material composed of hard, durable particles thoroughly cleaned, reasonably free from thin, flat or elongated pieces, frozen lumps, vegetable or other deleterious matter.

76.3 Physical Properties. The maximum percentage of deleterious substances shall not exceed the following values:

	Percentage by weight
Removed by decantation.....	1
Shale	1
Coal	1
Clay lumps	$\frac{1}{4}$
Soft fragments	5
Other local deleterious substances (such as alkali, friable, thin, elongated, or lami- nated pieces).....	2
Total shale, coal, clay lumps, and soft fragments	5

Percentage of wear—

Los Angeles Rattler, 100 revolutions, % max.....	10
Los Angeles Rattler, 500 revolutions, % max.....	45

When subjected to five alternations of the sodium sulfate soundness test loss shall not be more than 15 percent by weight.

76.4 Size Requirements. Coarse aggregate shall be well graded between the limits specified and the size or sizes designated shall conform to the following requirements:

PERCENTAGE BY WEIGHT PASSING LABORATORY SIEVE
WITH SQUARE OPENINGS

Sieve size, inches	No. 4 to $\frac{3}{4}$ -inch size	No. 4 to $1\frac{1}{2}$ -inch size	No. 4 to $2\frac{1}{2}$ -inch size	No. 4 to 3-inch size
$3\frac{1}{2}$	.....	.....	.....	100
3	.....	.....	100	95-100
$2\frac{1}{2}$	.....	.....	95-100	70-85
2	.....	100	70-85	
$1\frac{1}{2}$	.....	95-100	.....	40-75
1	100	.....	40-75	
$\frac{3}{4}$	95-100	35-70	.....	20-40
$\frac{3}{8}$	20-55	10-30	.....
No. 4	0-10	0-5	0-5	0-5

The above gradation represents the extreme limits which shall determine suitability for use from all sources of supply. Gradation from any one source shall be reasonably uniform and not subject to the extreme percentages of gradation specified above. Coarse aggregate from any one source having a variation in fineness modulus greater than 0.30 may be rejected.

76.5 Sampling and Testing. Sampling and testing of the coarse aggregate shall be in accordance with the following standard methods of the A. A. S. H. O. with subsequent amendments:

Sampling	A.A.S.H.O. T-2
Soft fragments.....	A.A.S.H.O. T-8
Coal	A.A.S.H.O. T-10
Shale	A.A.S.H.O. T-10
Loss by decantation.....	A.A.S.H.O. T-11
Size	A.A.S.H.O. T-27
Percentage of wear.....	A.A.S.H.O. T-96
Soundness	A.A.S.H.O. T-104

SECTION 77—GRAVEL FOR BEDDING AND BACKFILL FOR UNDERDRAINS

77.1 Material Covered. This specification covers the size and quality of gravel or crushed stone for bedding and backfill for underdrains.

77.2 General. Gravel or stone shall consist of reasonably tough, durable particles and shall not contain an injurious amount of alkali or organic matter. The quality of the material shall be subject to approval by the engineer.

77.3 Size of Bedding Material. Gravel or stone for bedding shall be well graded and shall pass a screen with one-inch square openings.

77.4 Size of Backfill Material. Gravel or stone for backfill shall be well graded and shall pass a screen with three-inch square openings and at least 90 percent shall be retained on a screen with three-quarter-inch square openings.

SECTION 78—STONE FOR MASONRY

78.1 Material Covered. This specification covers the quality and size of stone for rubble masonry, rubble gutters, and riprap.

78.2 Quality. Stone used in rubble masonry and riprap shall consist of tough, sound, and durable rock, free from seams, coatings, drys, or other imperfections, and of such character that it will not disintegrate from the action of water.

When tested by means of the Los Angeles Rattler according to Method T-96 of the A. A. S. H. O. the percentage of wear for 500 revolutions shall not be greater than 50 percent. Stone shall be angular in shape and shall have a rough surface such as will thoroughly bond with the surrounding mortar.

78.3 Size of Masonry Stone. Individual stones shall have a thickness of not less than eight inches and a width of not less than one and one-half times the thickness. No stones except headers shall have a length less than one and one-half times their width. The stones shall decrease in thickness from the bottom to the top of the wall.

78.4 Shaping Masonry Stone. Stones shall be roughly squared on joints, beds and faces. Selected stones roughly squared and pitched to line shall be used at all angles and ends of walls. Shaping or dressing of stones shall be done before the stones are laid in the wall.

78.5 Size of Riprap Stone. Size of riprap stone shall be as large as can be conveniently placed in the layer thickness specified. In layers two feet or less in thickness the stones, excepting spalls used to chink interstices, shall weigh not less than 50 pounds, and at least 60 percent of them shall weigh more than 100 pounds each. In layers more than two feet in thickness at least 50 percent of the mass shall be stones having a volume of two cubic feet or more.

78.6 Size of Rubble Stone for Gutters. Stones for rubble gutters shall be not less than six inches nor more than eight inches in thickness with approximately flat top surfaces and with a width of not less than two inches and a length of not less than six inches.

SECTION 79—FINE AGGREGATE FOR BITUMINOUS CONCRETE

79.1 Material Covered. This specification covers the quality and grading of sand for bituminous concrete mixtures.

79.2 General Requirements. The material may be either a natural or a manufactured product, or a combination of both. It shall be clean, hard grained, moderately sharp, and shall not contain more than three percent of clay or loam nor sufficient quantities of mica or other impurities to be detrimental. It also shall be suitable for mixing with the asphalt cement proposed for the work as determined by laboratory trial mixtures, stripping, and swell tests.

79.3 Size Requirements. When tested by means of laboratory sieves it shall meet the following requirements:

Laboratory sieve, square openings	Percentage by weight passing sieve
No. 4	100
No. 10	95-100
No. 40	55-75
No. 80	25-50
No. 200	0-12

79.4 Sampling and Testing. Sampling and testing shall be in accordance with the following standard test methods:

Sampling	A.A.S.H.O. T-2
Removed by decantation.....	A.A.S.H.O. T-11
Size	A.A.S.H.O. T-27
Stripping	Nevada Section 6
Swell	Nevada Section 6

SECTION 80—MINERAL FILLER

80.1 Material Covered. This specification covers the quality and grading of mineral filler for use in the construction of bituminous concrete pavements.

80.2 General Requirements. The mineral filler shall consist of limestone dust, Portland cement, or other inert mineral matter from sources approved by the engineer. It shall be suitable for mixing with fine aggregate and asphalt cement proposed for the work as determined by laboratory trial mixes, stripping, and swell tests.

80.3 Physical Properties. The material shall be thoroughly dry and free from lumps consisting of aggregations of fine particles. When tested by means of laboratory sieves it shall meet the following requirements:

Laboratory sieve, square openings	Percentage by weight passing sieve
No. 30	100
No. 80	95–100
No. 200	65–100

80.4 Sampling and Testing. Sampling and testing of mineral filler for use in the construction of bituminous concrete pavements shall be in accordance with the following standard test methods:

Size	A.A.S.H.O. T-37
Sampling	A.A.S.H.O. T-36
Swell	Nevada Section 6
Stripping	Nevada Section 6

SECTION 81—FINE AGGREGATE FOR PORTLAND CEMENT CONCRETE

81.1 Material Covered. This specification covers the quality and grading of fine aggregate for use in Portland cement concrete.

81.2 General Requirements. Fine aggregate for Portland cement concrete shall consist either of sand or other approved inert materials having similar characteristics or of a combination of the two, having hard, strong, durable particles.

81.3 Physical Properties. The maximum percentage of deleterious substances shall not exceed the following values:

	Percentage by weight
Removed by decantation.....	3
Coal	1
Clay lumps	1
Other local deleterious substances (such as shale, alkali, mica, coated grains, soft and flaky particles).....	3
Total coal, clay lumps, shale, soft fragments, and other local deleterious substances	5

All fine aggregate shall be free from injurious amounts of organic impurities. Aggregate subjected to the colorimetric test for organic impurities and producing a color darker than the standard shall be rejected unless they pass the mortar strength test as specified hereinafter.

When subjected to five alternations of the sodium sulfate soundness test the loss shall not be more than 10 percent by weight.

Fine aggregates, when subjected to the mortar strength test shall have a compressive strength at 7 and 28 days of not less than 95 percent of that developed by mortar of the same properties and consistency made of the same cement and Ottawa sand having a fineness modulus of 2.40 ± 0.10 .

81.4 Size Requirements. Fine aggregate shall be well graded and when tested by means of laboratory sieves shall conform to the following requirements:

Laboratory sieve, square openings	Percentage by weight passing sieve
$\frac{3}{8}$ inch	100
No. 4	95-100
No. 16	45-80
No. 50	5-30
No. 100	2-10

The above gradation represents the extreme limits which shall determine suitability for use from all sources of supply. Gradation from any one source shall be reasonably uniform and not subject to the extreme percentage of gradation specified above. Fine aggregate from any one source having a variation in fineness modulus greater than 0.20 may be rejected.

81.5 Sampling and Testing. Sampling and testing of fine aggregate shall be in accordance with the following standard methods of the A. A. S. H. O. with subsequent amendments:

Sampling	A.A.S.H.O. T-2
Coal	A.A.S.H.O. T-10
Shale	A.A.S.H.O. T-10
Removed by decantation.....	A.A.S.H.O. T-11
Organic impurities.....	A.A.S.H.O. T-21
Size	A.A.S.H.O. T-27
Mortar strength	A.A.S.H.O. T-71
Soundness	A.A.S.H.O. T-104

SECTION 82—SAND BLOTTER

82.1 Material Covered. This specification covers the quality and grading of sand for absorbing unpenetrated bituminous material applied as prime coat or seal coat.

82.2 General Requirements. The sand shall be reasonably free from clay, organic matter and other injurious impurities.

82.3 Size Requirements. The sand shall conform to the following sieve analysis:

Laboratory sieve, square openings	Percentage by weight passing sieve
No. 4	90-100
No. 16	30-75
No. 200	0-12

82.4 Sampling and Testing. Sampling and testing shall be in accordance with the following methods:

Sampling	A.A.S.H.O. T-2
Portion passing 200 mesh.....	A.A.S.H.O. T-11
Organic impurities.....	A.A.S.H.O. T-21
Size	A.A.S.H.O. T-27

SECTION 83—MORTAR SAND

83.1 Material Covered. This specification covers fine aggregate for use in cement mortar.

83.2 General Requirements. Sand for mortar shall consist of hard, strong, durable, uncoated mineral or rock particles, free from injurious amounts of organic or other deleterious substances.

83.3 Size Requirements. Sand for mortar shall conform to the requirements for fine aggregate for Portland cement concrete set forth in Section 81 of these specifications except that if the contractor so elects he may screen the sand over a No. 8 screen to produce the following grading:

Laboratory sieve, square openings	Percentage by weight passing sieve
No. 8	100
No. 50	15-40
No. 100	*0-10

*Weight removed by decantation not more than five percent.

83.4 Physical Properties. Mortar sand shall conform to the requirements for physical properties of fine aggregate for Portland cement concrete as set forth in Section 81 of these specifications.

83.5 Sampling and Testing. Sampling and testing of mortar sand shall be in accordance with the methods set forth in Section 81 of these specifications for sampling and testing fine aggregate for Portland cement concrete.

SECTION 84—LIQUID ASPHALT

84.1 Material Covered. This specification covers the quality of slow curing, medium curing, and rapid curing liquid asphalts for penetration treatments of road surfaces, roadmix surfaces, plantmix surfaces, and similar uses.

84.2 Test Reports, Shipping Notice, and Preliminary Sample. At the time of the contract award, the contractor shall furnish the department with the name and address of the company furnishing the asphalt. When required, representative samples of the asphalt shall be submitted for testing and approval prior to ordering shipment.

A metal seal shall be placed on each car showing the grade of asphalt contained therein.

The contractor shall furnish a shipping notice and test report for each carload of oil. One copy of each shall be mailed to the State Highway Engineer at Carson City, Nevada, and two copies of each shall be mailed to the Division Engineer of the Division to which shipment is made, one copy of which will in turn be forwarded to the inspector in charge of the project. Shipping notices shall be mailed immediately upon making shipment, and test reports shall be mailed as soon as tests have been completed which shall be within 48 hours after material has been shipped.

Shipping notices shall contain the following data:

Consignee	Car number
Project designation	Grade of material
Delivery point	Quantity loaded
Date shipped	Loading temperature
Net quantity	

Test reports shall show the following data:

Consignee	Date shipped
Project designation	Car number
Delivery point	Grade of material
All tests for specified grade	

84.3 Properties and Test Methods. Liquid asphalts shall be homogeneous and shall conform to the requirements set forth in the following tables:

LIQUID ASPHALT, RAPID CURING TYPES

A.A.S.H.O.

	Test	Method	RC-0	RC-1	RC-2	RC-3	RC-4	RC-5
Flash point (Tag. open cup) °F. min.	T-79	80	80	80	80	80	80	80
Viscosity, Sayboldt-Furol	T-72	.....	75-150	.....	.....	.....	.....	.....
At 77° F.	.....	.....	75-150	.....	.....	.....	.....	.....
At 122° F.	.....	.....	.....	.....	100-200	250-500	125-250	300-600
At 140° F.	.....	.....	.....	.....	.....	.....	.....	.....
At 180° F.	.....	.....	.....	.....	.....	.....	.....	.....
Distillation	T-78	.....	.....	.....	.....	.....	.....	.....
Distillate, percent by volume of total distillate to 680° F.—								
To 374° F., min.	.....	15	10	40	25	25	8	8
To 437° F., min.	.....	55	50	65	55	40	40	25
To 500° F., min.	.....	75	70	87	83	80	80	70
To 600° F., min.	.....	90	88	.....	.....	.....	.....	.....
Residue from distillation to 680° F., volume—								
Percent by difference, min.	.....	50	60	67	73	78	78	82
Tests on residue from distillation—								
Penetration at 77° F., 100 g., 5 sec.	T-49	80-120	80-120	80-120	80-120	80-120	80-120	80-120
Ductility at 77° F., cm. min.	T-51	100	100	100	100	100	100	100
Percent soluble in CCl_4 , min.	*T-44	99.5	99.5	99.5	99.5	99.5	99.5	99.5

All grades shall be free from water.

*Except that CCl_4 (C. P. grade) shall be used in place of CS_2 .

LIQUID ASPHALT, MEDIUM CURING TYPES

A.A.S.H.O.

Test	Method	MC-0	MC-1	MC-2	MC-3	MC-4	MC-5
Flash point (Tag, open cup) °F. min.	T-79	100	100	150	150	150	150
(Cleveland open cup) °F. min.	T-48	.....	.....	150	150	150	150
Viscosity, Saybolt-Furol	T-72	.....	.....	.....	.....	.....	.....
At 77° F.	75-150	75-150	75-150	75-150	75-150	75-150	75-150
At 122° F.	.....	.....	.....	.....	.....	.....	.....
At 140° F.	.....	.....	.....	.....	.....	.....	.....
At 180° F.	.....	.....	.....	.....	.....	.....	.....
Distillation	T-78	.....	.....	.....	.....	.....	.....
Distillate, percent by volume of total distillate to 680° F.—	.....	0-25	0-20	0-10	0-5	0	0
To 437° F.	.....	40-70	25-65	15-55	5-40	0-30	0-20
To 500° F.	.....	75-93	70-90	60-87	55-85	40-80	20-75
To 600° F.	.....	.....	.....	.....	.....	.....	.....
Residue from distillation to 680° F., volume—	.....	50	60	67	73	78	82
Percent by difference, min.	.....	.....	.....	.....	.....	.....	.....
Tests on residue from distillation—	.....	.....	.....	.....	.....	.....	.....
Penetration at 77° F., 100 g., 5 sec.	T-49	120-300	120-300	120-300	120-300	120-300	120-300
Ductility at 77° F. for residue of less than 200 penetration (cm.)	T-51	100+	100+	100+	100+	100+	100+
Ductility at 60° F. for residue of 200-300 penetration (cm.)	.....	100+	100+	100+	100+	100+	100+
Percent soluble in CCl_4 , min.	*T-44	99.5	99.5	99.5	99.5	99.5	99.5

All grades shall be free from water.

*Except that CCl_4 (C. P. grade) shall be used in place of CS_2 .

LIQUID ASPHALT, SLOW CURING TYPES

A.A.S.H.O.

Test	SC-0	SC-1	SC-2	SC-3	SC-4	SC-5	SC-6
Method	0.5	0.5	0.5	0.5	0.5	0.5	0.5
T-55	150	150	200	225	250	275	300
T-48							
T-72							
At 77° F.							
At 122° F.							
At 140° F.							
At 180° F.							
At 210° F.							
Alternate, float viscosity at 122° F...							
Distillation—							
Total distillate to 680° F., vol. %.....	T-78	15-40	10-30	5-25	2-15	0-10	0-5
Tests on Residue from Distillation—							
Float viscosity at 122° F.....	T-50	15-100	20-100	25-100	50-125	60-150	75-200
Percent soluble in CCl_4 , min.....	*T-44	99.5	99.5	99.5	99.5	99.5	99.5
Asphalt residue of 100 pen., % min.....	T-56	40	50	60	70	75	80
Ductility of asphalt residue at							
77° F., min.....	†T-51	100	100	100	100	100	100

*Except that CCl_4 (C. P. grade) shall be used in place of CS_2 .

†The ductility test shall be made on the residue from which the amount of asphalt of 100 penetration is determined. The residue shall be within the penetration range of 85 to 115.

SECTION 85—EMULSIFIED ASPHALT

85.1 Material Covered. This specification covers the quality of emulsified asphalts both penetration and mixing type.

85.2 Test Reports. Shipping Notice, and Preliminary Sample. At the time of the contract award the contractor shall furnish the department with the name and address of the company furnishing the emulsified asphalt. When required, representative samples of the emulsified asphalt shall be submitted for testing and approval prior to ordering shipment.

A metal seal shall be placed on each car showing the grade of emulsion contained therein.

The contractor shall furnish a shipping notice and test report for each carload of emulsion. One copy of each shall be mailed to the State Highway Engineer at Carson City, Nevada, and two copies of each shall be mailed to the Division Engineer of the Division to which shipment is made, one copy of which will in turn be forwarded to the inspector in charge of the project. Shipping notices shall be mailed immediately upon making shipment and test reports shall be mailed as soon as tests have been completed.

Shipping notices shall contain the following data:

Consignee	Car number
Project designation	Grade of material
Delivery point	Quantity loaded
Date shipped	Loading temperature
Net quantity	

Test reports shall show the following data:

Consignee	Date shipped
Project designation	Car number
Delivery point	Grade of material
All tests for specified grade	

85.3 Properties and Tests. Emulsified asphalt shall be homogeneous and shall be composed of a bituminous base uniformly emulsified with water and an emulsifying or stabilizing agent.

85.4 Bituminous Base. Emulsion shall contain not less

than 55 percent nor more than $62\frac{1}{2}$ percent of one of the following materials:

PENETRATION TYPE EMULSION

Liquid Asphalt SC-6 conforming to Section 84 of these specifications.

Asphalt Cement 150 to 200 penetration conforming to Section 86 of these specifications.

MIXING TYPE EMULSION

Liquid Asphalt SC-6 conforming to Section 84 of these specifications.

Asphalt Cement, 70 to 85 penetration conforming to Section 86 of these specifications.

Asphalt Cement, 150 to 200 penetration conforming to Section 86 of these specifications.

Asphalt emulsion shall conform to the following requirements for each type:

Specification Designation	Penetration Emulsion	Mixing Emulsion
Viscosity, S. F., seconds.....	20-55	20-55
Screen Test, max. percent.....	0.10	0.10
Demulsibility, percent.....	60 min.	30 max.
Settlement, 5 days, max. percent.....	3	5
Miscibility, with water.....	.....	No coagulation in 2 hours.
Coating Test.....	.....	No appreciable separation in 3 minutes.
Residue at 325° F., percent.....	55-62 $\frac{1}{2}$	55-62 $\frac{1}{2}$

85.5 Sampling and Testing. Sampling and testing of emulsified asphalt shall be in accordance with the following methods:

Viscosity	A.A.S.H.O. T-59
Screen Test.....	A.A.S.H.O. T-59
Demulsibility	A.A.S.H.O. T-59
Settlement in 5 days.....	A.A.S.H.O. T-59
Miscibility	A.A.S.H.O. T-59
Coating Test.....	A.A.S.H.O. T-59
Residue at 325° F.....	Nevada Section 6
Sampling	A.A.S.H.O. T-40

NOTE—Emulsified asphalt samples shall be shipped in clean glass containers.

SECTION 86—ASPHALT CEMENT

86.1 Material Covered. This specification covers quality of asphalt cement prepared from petroleum for use in bituminous mixes.

86.2 General Requirements. The asphalt cement shall be homogeneous, free from water, and shall not foam when heated to a temperature of 350° F.

86.3 Test Reports. Shipping Notice and Preliminary Sample. At the time of the contract award, the contractor shall furnish the department with the name and address of the company furnishing the asphalt. When required, representative samples of the asphalt shall be submitted for testing and approval prior to ordering shipment.

A metal seal shall be placed on each car showing the grade of asphalt contained therein.

The contractor shall furnish a shipping notice and test report for each carload of oil. One copy of each shall be mailed to the State Highway Engineer at Carson City, Nevada, and two copies of each shall be mailed to the Division Engineer of the Division to which shipment is made, one copy of which will in turn be forwarded to the inspector in charge of the project. Shipping notices shall be mailed immediately upon making shipment and test reports shall be mailed as soon as tests have been completed which shall be within 48 hours after material has been shipped.

Shipping notices shall contain the following data:

Consignee	Car number
Project designation	Grade of material
Delivery point	Quantity loaded
Date shipped	Loading temperature
Net quantity	

Test reports shall show the following data:

Consignee	Date shipped
Project designation	Car number
Delivery point	Grade of material
All tests for specified grade	

86.4 Properties. Asphalt cement shall conform to the following requirements:

	GRADE		
Specification designation	40 to 100	100 to 200	200 to 300
Flash point, Cl.O.C. °F. min.....	450	450	350
Penetration of original sample			
at 77° F.....	40 to 50	100 to 120	200 to 300
	50 to 60	120 to 150	
	60 to 70	150 to 200	
	70 to 85		
	85 to 100		
Loss on heating 5 hr. at 325° F., percent max.....	2	3	3.5
Penetration after loss on heating, percent of original min.....	80	75	65
Ductility at 77° F., cm. min.....	100	100	100
Solubility in CS ₂ , percent min.....	99.5	99.5	99.5
Solubility in CCl ₄ , percent min.....	99.0	99.0	99.0

86.5 Sampling and Testing. Sampling and testing of asphalt cement shall be in accordance with the following methods:

Flash point.....	A.A.S.H.O. T-48
Penetration	A.A.S.H.O. T-49
Loss on heating.....	A.A.S.H.O. T-47
Ductility	A.A.S.H.O. T-51
Solubility in CS ₂	A.A.S.H.O. T-44
Solubility in CCl ₄	A.A.S.H.O. T-45
Sampling	A.A.S.H.O. T-40

SECTION 87—ASPHALT JOINT FILLER

87.1 Material Covered. This specification covers the quality of asphalt to be used in filling joints in concrete work.

87.2 General Requirements. Asphalt joint filler for horizontal joints shall conform to the requirements of the A. A. S. H. O. Standard Specifications for Oil Asphalt Filler, M-18.

Filler for use in vertical joints shall be an asphalt conforming to the requirements specified above for horizontal joint filler to which has been added 20 percent by weight of asbestos filler. Incorporation of the asbestos filler with the asphalt shall be done at the factory of the manufacturer to insure uniform distribution of the filler throughout the mix.

SECTION 88—ASPHALT FOR WATERPROOFING

88.1 Prime Coat. Asphalt for prime coat for use with asphalt in waterproofing below and above ground level shall meet the requirements of A. S. T. M. designation D-41.

88.2 Main Coat. Asphalt for main coat shall conform to the following requirements:

Softening point.....	150° F. to 170° F.
Penetration.....	25 to 50
Flash point, min.....	400° F.
Loss on heating at 325° F., max.....	1 percent
Penetration after loss on heat- ing, percent of original, min.....	60 percent
Ductility at 77° F., min.....	5 cm.
Insoluble in CS ₂ , max. percent.....	1.0

88.3 Testing. Testing of asphalt for waterproofing shall be in accordance with the following methods:

Softening point.....	A.S.T.M. D-36
Penetration	A.S.T.M. D-5
Flash point.....	A.S.T.M. D-92
Loss on heating at 325° F.....	A.S.T.M. D-6
Penetration after loss on heating	A.S.T.M. D-5
Ductility at 77° F.....	A.S.T.M. D-113
Insoluble in CS ₂	A.S.T.M. D-4

SECTION 89—PORTLAND CEMENT

89.1 Material Covered. The Portland cements covered by these specifications are of five classes which are designated as follows:

Type I. For use in general concrete construction when the special properties specified for Types II, III, IV, and V are not required.

Type II. For use in general concrete construction when the special properties specified for Types III, IV, and V are not required, and when the chemical and physical test requirements prescribed for this type in the specifications are desired.

Type III. For use when high early strength is required.

Type IV. For use when low heat of hydration is required.

Type V. For use when high sulfate resistance is required.

The cements of types specified shall conform to the requirements of the A. A. S. H. O. M-85. Unless otherwise provided or called for in the Special Provisions, Type I cement shall be furnished.

89.2 Sampling and Testing. Sampling and testing of Portland cement shall be in accordance with A. A. S. H. O. T-1.

Cement may be sampled either at the mill or at the site of the work as provided in the above specifications. The seals of cars containing cement which has been sampled shall not be broken except by the engineer.

The contractor shall notify the engineer of dates of delivery so that there will be sufficient time for sampling the cement, either at the mill or upon delivery.

SECTION 90—STRUCTURAL, RIVET AND EYEBAR STEEL

90.1 General. All structural and eyebar steel, except when alloy steel is specified, shall conform to the requirements of the Standard Specifications for Steel for Bridges and Buildings, Designation A-7, of the American Society for Testing Materials, and all rivet steel shall conform to the requirements of the Standard Specifications for Structural Rivet Steel, Designation A-141 of that society. These requirements shall apply with subsequent amendments and additions thereto adopted by the society but are supplemented by the following requirements:

90.2 Mill Test Reports. Two certified copies of the mill test report showing the chemical and physical characteristics of each heat from which metal is used shall be furnished by the contractor.

90.3 Character of Fracture. Test specimens of structural, eyebar or rivet steel shall show a fracture having a silky or fine granular structure throughout, with bluish gray or dove color, and shall be entirely free from granular, black and brilliant specks.

90.4 Defects in Materials. Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges, and other defects; provided, however, that surface imperfections in material three-eighths inch or more in thickness may be corrected in the following manner:

When the imperfections are less than one-sixteenth inch in depth, they may be removed by grinding.

When imperfections are one-sixteenth inch or more in depth, they shall be chipped and, unless otherwise permitted by the engineer, they shall be welded in accordance with this specification. The maximum depth of any depression after chipping shall not exceed the following:

$\frac{1}{16}$ inch in metal from 0.375 to 0.499 inch in thickness.

$\frac{1}{8}$ inch in metal from 0.500 to 0.999 inch in thickness.

$\frac{3}{16}$ inch in metal from 1.000 to 1.499 inch in thickness.

$\frac{1}{4}$ inch in metal from 1.500 to 2.249 inch in thickness.

$\frac{3}{8}$ inch in metal from 2.250 to 3.500 inch in thickness.

The cross sectional area of the piece shall not be reduced at any point in its length more than one and one-half percent by the removal of the defects.

After removal of the defects and before any welding is done, the material shall be subjected to inspection by the engineer or his representative. All welding shall be done in the presence of the engineer or his representative. This inspection may be waived only upon written authorization of the engineer.

Upon approval of the chipped areas weld metal shall be deposited in the depression to a thickness extending at least one-sixteenth inch above the rolled surface. The welders shall be qualified for the work, and flux coated welding rods suitable to the grade of steel shall be used.

The deposited weld metal shall be sound, and free from excessive oxides, nonmetallic inclusions and gas pockets. It shall penetrate every recess in the rolled metal and shall be thoroughly fused with it on all surfaces and edges of fusion. Along the edge of the deposit, the weld metal shall merge into the metal with a gradual taper and shall have no reentrant projection or overlap.

In the welding operation the metal shall not be undercut along the edges of the welded area. All metal projections above the rolled surface of the welding shall be removed by chipping or grinding to produce a workmanlike finish.

All materials shall be free from mill scale, rust pits, or other defects affecting its strength.

90.5 Full Size Tests. When full size tests of built up structural members and eyebars are required by the contract, the contractor shall supply testing machines of the proper type and capacity, and shall provide all facilities and labor incidental to the making of the tests. In all tests involving the determination of tensile and compressive strengths, the ultimate strength, deformation, and other pertinent data shall be recorded.

When tests of full size eyebars are required, the number and size of the bars to be tested shall be designated by the engineer before the mill order is placed. The number shall not exceed five percent of the whole number of bars ordered, with a minimum of two bars on small orders.

Test bars shall be of the same section as the bars to be

used in the structure and of the same length if within the capacity of the testing machine. They shall be selected by the inspector from the finished bars, preferably after annealing. Test bars representing bars too long for the testing machine shall be selected from the full length bar after the heads on one end have been formed, and shall have the second head formed upon them after being cut to the greatest length which can be tested.

Full size tests of eyebars shall show a yield point of not less than 33,000 pounds per square inch, and an ultimate strength of not less than 60,000 pounds per square inch, and an elongation, including the fracture, of not less than 12 percent in a length of 18 feet measured in the body of the bar.

If an eyebar fails to fulfill the specified requirements, two additional bars of the same size and from the same melt shall be tested. The bars represented by the test may be reannealed before the additional bars are tested.

If two of the three bars fail to give satisfactory results, the bars of that size and melt shall be rejected.

A record of the annealing charges shall be furnished the engineer, showing the bars included in each charge and the treatment they received.

SECTION 91—MISCELLANEOUS METALS

91.1 Steel Forgings. Steel forgings shall conform to the requirements of the Standard Specifications for Carbon Steel Forgings for General Industrial Use, A. S. T. M. A-235, Class C-1, unless otherwise specified.

91.2 Steel Castings. Steel castings shall conform to the requirements of the Standard Specifications for Carbon Steel Castings for Miscellaneous Industrial Uses, A. S. T. M. A-27, Grade B-1, unless otherwise specified.

91.3 Gray Iron Castings. Gray iron castings shall conform to the requirements of the Standard Specifications for Gray Iron Castings, A. S. T. M. A-48, Class 40, unless otherwise specified.

91.4 Malleable Castings. Malleable iron castings shall conform to the requirements of the Standard Specifications for Malleable Iron Castings, A. S. T. M. A-47, Grade 32510, unless otherwise specified.

91.5 Wrought Iron Plates. Wrought iron plates shall conform to the requirements of the Standard Specifications for Wrought Iron Plates, A. S. T. M. A-42.

91.6 Rolled Wrought Iron Shapes and Bars. Wrought iron bars shall conform to the requirements of the Standard Specifications for Rolled Wrought Iron Shapes and Bars, A. S. T. M. A-207.

91.7 Bronze. Bronze for bearing plates shall conform to the requirements of the Tentative Specifications for Bronze Castings for Turntables and Movable Bridges and for Bearing and Expansion Plates of Fixed Bridges A. S. T. M. B-22, Class B, unless otherwise specified.

91.8 Sheet Copper. Sheet copper shall conform to the requirements of the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars A. S. T. M. B-4, or to the requirements of the Standard Specifications for Fire Refined Copper other than Lake, A. S. T. M. B-72.

SECTION 92—REINFORCEMENT

92.1 Bar Reinforcement. Bar reinforcement for concrete shall conform to the requirements of Specification M-31 of the A. A. S. H. O. with the following modifications:

1. All bars shall be of the deformed type unless otherwise specified.

2. All bars for use in concrete structures shall be "Structural Steel Grade," open hearth process, unless otherwise specified. Either "Structural Steel Grade," or "Intermediate Grade" may be used for all other concrete reinforcement.

3. The type of deformation shall be subject to the approval of the engineer.

92.2 Wire and Wire Mesh. Wire and wire mesh, when used as reinforcement in concrete shall conform to the requirements of Specification M-55 of the A. A. S. H. O. The type of mesh shall be approved by the engineer.

92.3 Bar Mat Reinforcement. Bar mat reinforcement for concrete shall conform to the requirements of Specification M-54 of the A. A. S. H. O.

92.4 Structural Shapes. Structural shapes used as reinforcement in concrete shall conform to the requirements for structural steel as provided in these specifications.

SECTION 93—HARDWARE

93.1 Material Covered. This specification covers the quality of bolts, nuts, washers, drift pins, dowels, nails, spikes, and other metal fastenings.

93.2 General Requirements. Hardware for use with redwood, Port Orford cedar, or treated Douglas fir shall be galvanized. Unless otherwise specified on the plans, hardware for use with other timber need not be galvanized.

93.3 Bolts, Dowels, and Drift Pins. Bolts, dowels, and drift pins shall conform to the Standard Specifications for Steel for Bridges and Buildings Serial Designation A-7 of the A. S. T. M. Bolts and nuts shall have square heads.

93.4 Washers. Washers shall be standard cast O-gee or malleable cast washers, or they may be cut from medium steel or wrought iron plates as specified.

93.5 Nails and Spikes. Nails shall be cut or round wire of standard form. Spikes shall be cut or wire spikes, or boat spikes, as specified.

93.6 Galvanizing. Galvanizing on hardware shall conform to Specification A-153 of the A. S. T. M.

SECTION 94—CORRUGATED METAL CULVERT PIPE

94.1 Material Covered. This specification covers the quality of corrugated metal culvert pipe for use in culverts and drains.

94.2 Base Metal. Corrugated metal pipe culverts shall be fabricated from corrugated galvanized sheets the base metal of which shall be made by either the open hearth process or a process that produces genuine wrought iron. The base metal shall conform to one of the chemical requirements of Table I.

TABLE I

Elements	CHEMICAL COMPOSITION BY LADLE ANALYSIS (Position of base metals does not indicate preference)					Tolerance by check analysis of finished sheets
	Pure iron	Copper bearing pure iron	Copper iron	Copper molybdenum iron	Copper steel	
Carbon, maximum percent.....	----	----	----	----	----	.05 .01
Manganese, maximum percent.....	----	----	----	----	----	.06 .01
Phosphorus, maximum percent.....	.015	.015	.015	.015	----	.12
Sulphur, maximum percent.....	.040	.040	.040	.040	.050	.04 .01
Silicon, maximum percent.....	----	----	----	----	----	.15
Copper, minimum percent.....	----	.20	.20	.40	.20	----
Molybdenum, minimum percent.....	----	----	----	.05	----	----
Sum of first 5 elements, maximum percent.....	----	.10	.25	.25	.70	.42 .04
Sum of first 6 elements, maximum percent.....	.10	----	----	----	----	----

*Genuine wrought iron is a combination of iron and silicate slag. The above analysis covers the metalloids found in both the base iron and the silicate slag. It is defined as a ferrous material aggregated from a solidifying mass of pasty particles of highly refined metallic iron, with which, without subsequent fusion, is incorporated a minutely and uniformly distributed quantity of slag. All sheet bars shall be made from wrought iron blooms, and shall be entirely free from any admixture of steel. Genuine wrought iron sheets shall be rolled only from such bars.

94.3 Rivets. Rivets shall be of the same material as the base metal specified for the corrugated sheets. They shall be thoroughly galvanized or sherardized.

94.4 Spelter Coating. Base metal sheets shall be galvanized on both sides by the hot dip process, after which these sheets may be sheared to proper sizes. A coating of prime western spelter or its equal shall be applied at the rate of not less than two ounces per square foot of double exposed surface. If the average spelter coating as determined from the required samples is less than two ounces of spelter per square foot, or if any one specimen has less than one and eight-tenths ounces of spelter per square foot of double exposed surface, the lot sampled shall be rejected. The finished sheets shall be of first class commercial quality, free of injurious defects, such as blisters, flux, and uncoated spots.

94.5 Design. The lengths of sheets, widths of laps, standard gages and computed weights per linear foot of the finished culverts, shall be as specified in Table II. The dimensions given in that table for diameter of pipe are nominal. The average weight per linear foot of finished culvert, exclusive of end finish, shall not underrun the computed weight specified by more than five percent.

TABLE II

Nominal diameter (inches)	Length of sheet before forming (inches)	Minimum width of lap (inches)	Galvanized sheet gage number	Computed weight per linear foot of finished culvert exclusive of end finish (pounds)	Connecting bands galvanized sheet gage number (or heavier)
8	28½	1½	16	7.3	16
10	35	1½	16	9.0	16
12	41	1½	16	10.5	16
15	50½	1½	16	12.9	16
18	60	1½	16	15.3	16
21	69½	1½	16	17.7	16
24	80	2	14	25.2	16
30	98	2	14	30.9	16
36	117	2	12	51.0	14
42	137	3	12	59.5	14
48	156	3	12	68.0	14
54	1-80 1-98	3	12	77.8	14
60		3	10	108.9	12

In fabricating 42- and 48-inch sizes two sheets may be used by allowing sufficient total sheet lengths to provide for an additional standard lap.

The gages of the sheets shall be increased if so indicated

on the plans for culverts under high fills. In such cases any connecting bands shall be of a gage not more than two numbers higher than that of the sheets connected, and in any case shall not be higher than 16 gage.

94.6 Gage Determinations and Tolerances. The gage of the culvert metal shall be determined from the weights of the galvanized sheets. The theoretical weights per square foot, together with permissible tolerances, on the flat galvanized sheets shall be as indicated in Table III.

TABLE III
Theoretical Weights of Galvanized Sheets and
Permissible Tolerances

Galvanized sheet (Gage)	Theoretical weight of galvanized sheet (Oz. per sq. ft.)	PERMISSIBLE TOLERANCES IN WEIGHTS OF SHEETS, PLUS OR MINUS IN PERCENTAGE OF THEORETICAL WEIGHT*		
		All of one gage and size in shipment† (Percent)	Single packages (Percent)	Single sheets (Percent)
8	112.5	5	7	10
10	92.5	5	7	10
12	72.5	5	7	10
14	52.5	5	7	10
16	42.5	5	7	10

*References are to gross weights of bundled material and to net weights of crated and boxed material. If the minimum or maximum only be ordered, double tolerance is to be taken on permissible side.

†Applies only to lots of 6,000 pounds or more.

94.7 Corrugations. Corrugations shall be not less than two and one-quarter inches nor more than two and three-quarters inches center to center. Corrugations shall have a depth of not less than one-half inch.

94.8 Perforated Pipe. Perforations shall be one-quarter inch in diameter, punched after the pipe has been galvanized. They shall be punched on centers spaced one and one-half inches lengthwise of the sheets so as to be in inside ridges of all but the end corrugations of each culvert section. The number of longitudinal rows of perforations shall conform to the following table:

Diameter of pipe, inches.....	8	10	12	15	18	21	24	30
Number of rows of holes....	8	8	10	10	15	15	20	20

94.9 Rivets and Riveting. Rivets shall be of the following diameters for the gage numbers specified.

TABLE B

Gage number	Diameter, inch	Gage number	Diameter, inch
16.....	5/16	10.....	3/8
14.....	5/16	8.....	3/8
12.....	3/8		

All rivets shall be driven cold in such a manner that the plates are drawn tightly together throughout the entire lap. No rivet center shall be closer to the edge of the metal than twice the rivet diameter. All rivets shall have neat, workmanlike, and full hemispherical heads of a form acceptable to the engineer, shall be driven without bending, and shall completely fill the holes. Longitudinal laps shall be riveted with one rivet in the valley of each corrugation. The longitudinal laps in all pipe 42 inches or more in diameter shall be double riveted. Circumferential shop riveted laps shall have a maximum rivet spacing of six inches, except that six rivets will be sufficient in twelve-inch pipe.

94.10 Net Length of Pipe. The lengths of pipe shall be the net length of the finished pipe which shall not include any material used to obtain an end finish on the pipe. If the average deficiency in any length of any shipment of pipe is greater than one percent, the shipment shall be rejected.

94.11 End Finish. The inlets and outlets of all culverts fabricated of 16 or 14 gage sheets shall be reinforced in a manner approved by the engineer, when so specified.

94.12 Asphaltic Coating. Unless otherwise specified, pipe culverts and band couplings shall be coated with an approved asphaltic pipe dip at the plant before being shipped. The quality and character of the dip and the method of application shall be such that the coating on the pipe will be tough and pliable and adhere firmly to the spelter.

94.13 Coupling Bands. Field joints shall be made with bands of the same base material as the culvert. The bands shall be seven inches wide for culverts with diameters of eight to 30 inches, inclusive, not less than 12 inches wide for culverts with diameters 36 to 48 inches, inclusive, and not less than 24 inches wide for culverts with diameters

54 to 60 inches, inclusive. Such bands shall be so constructed as to lap on an equal portion of each of the culvert sections to be connected, and shall be connected at the ends by galvanized angles having minimum dimensions of two inches by two inches by three-sixteenths inch. The seven-inch bands shall have at least two galvanized bolts of not less than one-half inch diameter. The 12-inch bands shall have three and the 24-inch bands shall have five one-half inch bolts. Other equally effective methods of connecting the coupling bands may be used if approved by the engineer.

94.14 Siphon Pipe. Corrugated metal pipe for use as siphons shall be close riveted and soldered, and so fabricated as to require a minimum number of field connections. Rivets on circumferential seams shall be spaced at approximately two and one-half inch centers with a maximum spacing of three inches. Circumferential and longitudinal seams on the outside of the pipe, where the edges of the sheets lap, shall be soldered in a workmanlike manner, the solder being sweated into the joints by means of a torch properly regulated for the purpose. Soldering irons shall not be used on factory seams. Sections of siphon pipe shall be joined in the field by means of an approved watertight coupling.

94.15 Corrugated Metal Arch Pipe. When corrugated metal arch pipe culverts are required by the plans or special provisions, the culvert pipe shall have an approved arch shape of approximate semicircular cross section, similar to that shown on the plans. Lap joints shall be staggered so as to alternate on each side of the center of the top of the arch.

94.16 Dimensions and Weights. The lengths of sheets, widths of laps, gages and computed weights per linear foot of corrugated metal arch pipe culverts shall be as specified in the following table:

TABLE C

Nominal horiz. diam. (Inches)	Nominal vert. diam. (Inches)	Minimum width of lap (Inches)	Galvanized sheet gage (Number)	Computed weight per linear foot of finished culvert exclusive of end finish	Connecting bands galvanized sheet gage number (or heavier)
21½	13½	1½	16	15.3	16
30	17	1½	14	25.2	16
37	21	2	14	30.9	16
44	25	2	12	51.0	14
59	34	3	12	68.0	14

94.17 Coupling Bands. Widths of coupling bands for corrugated metal arch pipe culverts shall be as follows:

TABLE D

CULVERT SIZE		Minimum width of coupling band (Inches)
Nominal horiz. diam. (Inches)		
21½	13½	7
30	17	7
37	21	7
44	25	12
59	34	12

94.18 Mill and Factory Inspection. If the engineer so elects, he may have the material inspected and sampled in the rolling mill or in the shop where fabricated. He may require from the mill a chemical analysis of any heat. The inspection, either in the mill or in the shop, shall be under the direction of the engineer. The engineer or his representative shall have free access to the mill or shop for inspection, and every facility shall be extended to him for the purpose. Inclusion in any lot of any material or pipe previously rejected at the mill or shop, will be considered sufficient cause for rejection of the entire lot.

94.19 Accepted Brands of Metal. No metal will be accepted until after the sheet manufacturer's certified analysis and manufacturer's guarantee have been passed upon by the engineer and accepted.

Misbranding or other misrepresentation, and nonuniformity of product will each be considered as sufficient reason to discontinue the acceptance, under this specification,

of any brand found unsatisfactory in any of these respects. Notice sent to the sheet manufacturer of the discontinuance of acceptance of this brand will be considered to be notice to all culvert companies handling that particular brand. One brand and one brand only, shall be approved for each kind of base metal furnished by each of the actual manufacturers of the sheets.

94.20 Sheet Manufacturer's Certified Analysis. The manufacturer of each brand shall file with the engineer a certificate setting forth the name or brand of metal to be furnished and a typical analysis showing the respective percentages of carbon, manganese, phosphorus, sulphur, silica, and copper; also of molybdenum when it is to be a constituent of a particular kind of base metal to be used. The certificate shall be sworn to for the manufacturer by a person having legal authority to bind the company.

94.21 Sheet Manufacturer's Guarantee. The manufacturer of the sheets shall submit with the certified analysis a guarantee providing that all metal furnished shall conform to the certified analysis filed, that it shall bear a suitable identification brand or mark, and that it shall be replaced without cost to the purchaser when not in conformity with the specified analysis, gage, or spelter coating. The guarantee shall be so worded as to remain in effect so long as the manufacturer continues to furnish material of the brand guaranteed.

94.22 Identification. No culverts will be accepted unless the metal is identified by a stamp on each section showing:

1. Name of sheet manufacturer
2. Name of brand and kind of base metal
3. Gage number
4. Weight of spelter coating
5. Identification symbols showing heat number and pot number

provided, however, that identification symbols showing heat numbers shall not be required for wrought iron, but identification by pot number will be required.

The identification of brands shall be placed on the sheet by the manufacturer of the sheets in such a way that when rolled into culverts the identification will appear on the

outside of each section of pipe. Pipes having any sections not so stamped shall be rejected. The kind of base metal shall be designated independently of the brand or trade mark so as to identify clearly the base metal furnished as being of the kind listed in the heading in the table. The designation of the "kind of base metal" may be indicated by placing on each sheet the initials of the exact name of the base metal used therein as the name appears in the table that follows:

- P I for pure iron.
- C B P I for copper bearing pure iron.
- C I for copper iron.
- C M I for copper molybdenum iron.
- C S for copper steel.
- G W I for genuine wrought iron.

94.23 Workmanship. It is the essence of these specifications that in addition to compliance with the details of construction, the completed pipe shall show careful, finished workmanship in all particulars. Culvert pipe on which the spelter coating has been bruised or broken either in the shop or in shipping, or which shows defective workmanship shall be rejected. This requirement applies not only to the individual pipe, but to the shipment on any contract as a whole. Among other, the following defects are specified as constituting poor workmanship and the presence of any or all of them in any individual culvert pipe or in general in any shipment shall constitute sufficient cause for rejection.

1. Uneven lap.
2. Variation from specified shape.
3. Variation from a straight center line.
4. Ragged or diagonal sheared edges.
5. Loose, unevenly lined or spaced rivets.
6. Poorly formed rivet heads.
7. Unfinished ends.
8. Illegible brands.
9. Lack of rigidity.
10. Bruised, scaled, or broken spelter coating.
11. Dent or bends in the metal itself.

94.24 Samples. Chemical analysis of the base metal of

the finished sheets, when required, may be made using samples taken for testing of weight of spelter coating. For testing the coating of sheets before the culverts are fabricated, a sample strip about three inches wide shall be cut crosswise or diagonally across the full width of one sheet of each lot bearing the sample identification symbol. From this strip and along the newly sheared edge, samples two and one-quarter inches square shall be cut from the middle and near each end. For testing coating of fabricated culverts, at least one sample two and one-quarter inches square, or a sample of equivalent area, shall be selected from each 20 culverts of a shipment, provided that not less than three samples, each from a different section, shall represent any one shipment.

94.25 Analysis of Finished Sheets. When not otherwise provided, chemical analysis, when required, shall be made according to the A. S. T. M. Designation E-30.

94.26 Tests for Spelter Coating. The tests for weight of spelter coating shall be made in accordance with A. A. S. H. O. Method T-65.

94.27 Field Inspection and Acceptance. The field inspection shall be made by the engineer who shall be furnished by the seller with an itemized statement of the sizes and lengths of culvert pipe in each shipment. The inspection shall include an examination of the culvert pipe for deficiency in lengths of sheets used, nominal specified diameter, net length of finished culvert pipe, and any evidence of poor workmanship as outlined above. The inspection may include the taking of samples for chemical analysis, and determination of weights of spelter coating. The pipe making up the shipment shall fully meet the requirements of these specifications, and if 25 percent of the pipe in any shipment fails to meet these requirements, the entire shipment may be rejected.

SECTION 95—SECTIONAL PLATE PIPE AND ARCHES

95.1 Material Covered. This specification covers the quality of sectional plate pipe and arches for use in culverts and drains.

95.2 Materials. Materials shall conform to the requirements of Section 94 except as modified herein.

95.3 Description of Plates. Plates shall consist of structural units of galvanized corrugated metal. Standard plates shall have a covering width of not less than 47 inches, measured along the neutral axis of the plate, and shall be available in nominal lengths of 10 feet, seven and one-half feet, five feet, and two and one-half feet (plates have approximately a two-inch lip beyond each end crest, which results in the actual length of a given structure being approximately four inches longer than the nominal length, except when skewed or beveled. In constructing footings for arches, this additional length must be provided for). A coating of prime western spelter or equal shall be applied by the hot dip process at the rate given below per square foot of double exposed surface.

Pipe 60 to 120 inches in diameter (inclusive) and arches :

8 to 10 gage, inclusive, 2 oz.

1 to 7 gage, inclusive, 3 oz.

Pipe 135 to 180 inches in diameter (inclusive), 3 oz.

If the average spelter coating as determined from the desired samples is less than that specified above, or if any one specimen shows a deficiency of 0.2 ounces where a 2-ounce coating is specified, or a deficiency of 0.3 ounce in the case of a 3-ounce coating requirement, the lot sampled shall be rejected. Spelter coats shall be of first-class commercial quality, free from injurious defects, such as blisters, flux, and uncoated spots. All pipes and arches for which 3-ounce spelter is required shall be galvanized after fabrication. When gages number eight and lighter are used, the metal may be galvanized either before or after fabrication.

Bolts for connecting plates shall be not less than eleven-sixteenth inch in diameter and shall be galvanized. The

threads shall be American National Coarse Thread Series, Class 2 fit. Bolts shall meet the following physical test requirements:

Minimum tensile strength.....	110,000 lbs. per sq. in.
Minimum shear.....	80,000 lbs. per sq. in.
Minimum reduction of area..	35 percent
Brinell hardness between the limits.....	241-286

The tests shall be made on the finished bolts. Unless otherwise provided the bolts shall be furnished so they may be sampled and tested before erection is commenced.

Bolt heads and nuts shall be specially designed to provide even and uniform bearing on the curved corrugated surfaces, or special washers shall be used in lieu thereof.

The plates at longitudinal and circumferential seams shall be connected by bolts. Circumferential seams shall be staggered, so that no circumferential seam shall be continuous for a greater distance than the width of the plate.

95.4 Forming and Punching of Plates. Each plate shall be curved to the proper radius and the bolt holes shall be so punched that all except end plates shall be interchangeable in the erection process. Bolt holes along those edges of the plates that will form longitudinal seams in the finished structure shall be staggered in rows two inches apart, with one row in the valley and one in the crest of the corrugation.

Bolt holes along those edges of the plates that will form circumferential seams in the finished structure shall provide for a bolt spacing of approximately 12 inches. The center of no hole shall be closer to the edge of the plate than one and three-quarters times the diameter of the bolt.

Bolt holes in plates seven to one gage, inclusive, shall be punched before plates are galvanized.

When the completed structure is to be full circle, pipe plates shall be so curved that when bolted together, true circles shall be formed of the required diameter. The diameter of the pipe in inches, divided by 15, shall determine the number of plates required to make a full circle, unless otherwise shown on the plans.

Plates for forming skewed or sloped ends shall be cut

so as to give the angle of skew or slope specified. Burnt edges shall be free from oxide and burrs, shall present a workmanlike finish, and legible identification numerals shall be placed on each part plate to designate its proper position in the finished structure.

95.5 Corrugations. Corrugations shall have a pitch of six inches with a tolerance of one-quarter inch and a depth of one and one-half inches, with a tolerance of plus or minus one-eighth inch.

95.6 Mill or Factory Inspection. Where mill or factory inspection is employed, gage shall be determined by the weight of flat plates before corrugating. Theoretical weights and tolerances shall be as follows:

Gage	Theoretical wt. before galvanizing	Theoretical wt. after galvanizing	PERMISSIBLE VARIATION IN AVG. WT. OF LOTS*	
	(lbs./sq. ft.)	(lbs./sq. ft.)	Over	Under
1	11.25	11.438	4	3
3	10.00	10.188	4	3
5	8.75	8.938	4.5	3
7	7.50	7.688	4.5	3
8	6.875	7.031	5	5
10	5.625	5.781	5	5

*The term "lot" means all the plates of one gage in the shipment, for gages seven and heavier, and not less than 6,000 pounds constitutes a "lot" for gages eight and lighter. Individual plates shall not underrun the theoretical weights by more than 10 percent.

SECTION 96—VITRIFIED CLAY CULVERT PIPE

96.1 Material Covered. This specification covers the quality of vitrified clay culvert pipe for installation as culverts under the roadway. Culvert pipe furnished under these specifications shall be of a single class to be designated as vitrified clay culvert pipe.

96.2 Material and Manufacture. Vitrified clay culvert pipe shall conform to the requirements of the A. A. S. H. O. Standard Specification for Clay Pipe M-65.

96.3 Sampling and Testing. Sampling and testing of vitrified clay culvert pipe shall be in accordance with A. A. S. H. O. Standard Method T-33.

SECTION 97—REINFORCED CONCRETE CULVERT PIPE

97.1 Material Covered. This specification covers reinforced concrete pipe intended to be used for the construction of culverts.

Reinforced concrete culvert pipe shall be standard strength, extra strength, or a special D-load strength.

97.2 Manufacture. Reinforced concrete culvert pipe shall conform to the requirements of the American Society for Testing Materials Standard Specification for Reinforced Concrete Culvert Pipe Serial Designation C-76 with subsequent amendments, except as herein specifically modified for pipe manufactured by the centrifugal process.

97.3 Centrifugal Pipe. Centrifugal reinforced concrete pipe shall be formed and compacted by centrifugal force in a machine of suitable type so designed that the pipe forms may be revolved without harmful vibration at sufficient speeds to insure even distribution and dense packing of the concrete.

Filling of the forms and spinning of the pipe shall be a continuous operation and the spinning of each section shall take place before any of the concrete in the form has taken an initial set.

After the concrete has been densely packed, all water, laitance, and float material expelled from the concrete shall be removed and the inner surface smoothed, preparatory to the second and final spinning.

For various sizes of centrifugal pipe the minimum wall thickness shall conform to the following table, which is intended to represent the wall thickness for centrifugal pipe which will meet the requirements for standard strength reinforced culvert pipe. The wall thickness for extra strength pipe shall be increased over the thickness shown in the following table, sufficiently to produce pipe which will meet the requirements for extra strength reinforced concrete culvert pipe.

Diameter of centrifugal pipe (Inches)	Minimum wall thickness (Inches)
12	1 $\frac{3}{8}$
15	1 $\frac{1}{2}$
18	1 $\frac{3}{4}$
24	2 $\frac{1}{2}$
30	2 $\frac{3}{4}$
36	3
42	3 $\frac{3}{4}$
48	4
54	4 $\frac{1}{2}$
60	5
72	6
84	7

Minimum wall thicknesses of intermediate diameters should be in proportion to the minimum wall thicknesses specified above.

In addition to the marking requirements specified under specification C-76 of the A. S. T. M., centrifugal pipe shall be marked with the D-loading for which the pipe has been tested. The D-load is the actual load per linear foot of pipe, divided by the inside diameter of the pipe in feet, which the pipe will withstand under the three-edge-bearing test without showing cracks in excess of the requirements of Specification C-76 of the A. S. T. M.

SECTION 98—PLAIN CONCRETE CULVERT PIPE

98.1 Material Covered. This specification covers plain concrete pipe intended to be used for the construction of culverts.

The acceptability of pipe shall be determined by the results of the strength and absorption tests specified herein, if and when required and by inspection to determine whether the pipe conforms to these specifications as to design and freedom from defects.

98.2 Materials. Materials used in the manufacture of plain concrete culvert pipe shall conform to the requirements of Part III, Material Details. Specific references to Part III are as follows:

Coarse aggregate for concrete.....	Section 76
Fine aggregate for Portland cement concrete.....	Section 81
Portland cement	Section 89

The aggregate shall be so graded and proportioned and thoroughly mixed in a batch mixer with such proportions of cement and water as will produce a homogeneous concrete mixture of such quality that the pipe will conform to the test and design requirements of these specifications. The shell thickness, minimum strength requirements, and absorption shall be in accordance with Table I which follows:

TABLE I
PLAIN CONCRETE CULVERT PIPE

Internal diameter,* inches	Wall thickness, minimum, inches	MINIMUM AVERAGE CRUSHING STRENGTH Pounds Per Linear Foot			Average absorption, maximum percent
		Three-edge bearing method	Sand-bearing method		
12	1 $\frac{3}{4}$	2,000	3,000	8	
15	2	2,500	3,750	8	
18	2	3,000	4,500	8	
24	2 $\frac{1}{2}$	4,000	6,000	8	
30	3	5,000	7,500	8	
36	3 $\frac{3}{8}$	6,000	9,000	8	

*If it is necessary to increase the wall thickness over the amount indicated in order to meet crushing strength requirements, the internal diameter may be decreased by not more than three percent and the amount so decreased shall be added to the wall thickness.

98.3 Design. The shell thickness shall not be less than that given in the table. The contractor may submit, for approval, designs other than those given in the table, provided that such pipe shall meet the same physical tests and inspection requirements as herein prescribed for the pipe for which it is substituted.

The ends of the pipe shall be of such design that the pipe when laid shall form a continuous conduit with a smooth and uniform interior surface.

98.4 Curing. Pipe shall be subjected to any one of the methods of curing described in the following paragraphs or to any other method approved by the engineer that will give satisfactory results:

(a) Pipe may be placed in a curing chamber, free from outside drafts, where the pipe shall be subjected to the action of thoroughly saturated steam at a temperature between 100° and 130° F. for a period of not less than 36 hours, or, when necessary, for such additional time as may be needed to enable the pipe to meet the strength requirements. (See Note.)

When a curing chamber is not available, pipe may be placed in an enclosure of canvas or other closely woven material and subjected to saturated steam at the temperature and for the time specified above. The enclosure shall

be so erected as to allow full circulation of steam around the entire pipe. The interior surfaces of the curing room or canvas jackets and the surfaces of the pipe shall be entirely moist at all times.

(b) Under the conditions of enclosure prescribed in paragraph (a), pipe may be cured by subjecting it to a continuous or frequently applied fine spray of water in an enclosure maintained at a temperature of not less than 70° F. for a period of not less than 72 hours, or such additional time as may be necessary to meet the strength requirements. (See Note.) If the enclosure is maintained at a temperature of less than 70° F., the curing period shall be increased as may be necessary to meet the strength requirements.

(c) The sides and top of each pipe may be covered with heavy burlap, or other suitable material, saturated with water before applying and kept saturated with water at a temperature of not less than 70° F. for 72 hours, or such additional time as may be necessary to meet the strength requirements. (See Note.) The ends of the pipe shall be so enclosed as to prevent the free circulation of air through or around the pipe. If the temperature of the water is less than 70° F., the curing period shall be increased as may be necessary to meet the strength requirements.

NOTE—When high early strength Portland cement is used, the time of curing specified for each of the methods prescribed may be reduced to 24 hours, or such additional time as may be necessary to meet the requirements of the engineer.

98.5 Physical Test Requirements. The ultimate load, as determined by either the sand-bearing or three-edge-bearing test shall be not less than the ultimate load specified in the table.

The absorption shall not exceed eight percent of the dry weight. Pipe shall be considered as conforming to these specifications for absorption when not less than 80 percent of the number of specimens tested, including any retested, conform to the test requirements. When the initial absorption specimen from a pipe fails to conform to these specifications, the absorption test shall be made on another specimen from the same pipe and the results of the retest shall be substituted for the original test results.

The contractor shall furnish upon request for test purposes a number of pipe not to exceed two percent of total number of each size required, but not to exceed five pieces of any one size. The specified number of pipe shall be furnished without charge and shall be selected at random by the engineer from pipe which would not otherwise be rejected under these specifications. The contractor shall also furnish all facilities necessary for determining the crushing strength of specimens.

Should any specimen fail to meet the requirements for strength, a retest will be allowed on two similar specimens for each specimen in each lot that failed, and the pipe shall be acceptable only when all these retest specimens fulfill the test requirements.

98.6 Size and Permissible Variation. Pipe of the internal diameters listed in the table shall be the standard sizes for culvert construction.

Variation of the internal diameter shall not exceed one percent for pipe having an internal diameter of 36 inches or less. The shell thickness shall not be less than that intended in the design by more than five percent at any point.

98.7 Workmanship and Finish. Pipe shall be substantially free from fractures, large or deep cracks, and surface roughness. The planes of the ends of the pipe shall be perpendicular to the longitudinal axis.

98.8 Marking. The following shall be clearly stenciled on the pipe:

- (a) The date of manufacture.
- (b) The name or trade mark of the manufacturer.

98.9 Inspection and Rejection. Pipe shall be considered ready for shipment when they conform to the requirements as indicated by the specified tests.

All materials, processes of manufacture, and finished pipe shall be subject to inspection and approval by the engineer.

Pipe shall be subject to rejection on account of failure to meet any of the specification requirements or on account of any of the following:

(a) Fractures or cracks passing through the shell, except that a single end-crack that does not exceed in length the

depth of the joint shall not be cause for rejection. If a single end-crack that does not exceed the depth of the joint exists in more than 10 percent of the pipe inspected, however, the defective pipe shall be rejected.

(b) Defects which indicate imperfect mixing and molding.

(c) Surface defects indicating honey-combed or open texture.

(d) Spalls deeper than one-half the depth of the joint or extending more than four inches around the circumference. If spalls not deeper than one-half the depth of the joint or extending not more than four inches around the circumference exist in more than 10 percent of the pipe, however, the defective pipe shall be rejected.

98.10 Methods of Testing. Testing of concrete culvert pipe shall be in accordance with Standard Method T-33 of the A. A. S. H. O.

SECTION 99—SEWER PIPE

99.1 General. Sewer pipe shall conform to the requirements of A. S. T. M. Specification C-13 with subsequent amendments.

SECTION 100—TIMBER

100.1 Description. This specification covers structural timber and lumber used in the construction of bridges, culverts, and miscellaneous wood construction.

100.2 Materials. All timber and lumber shall be of the species and grades called for on the plans or in the special provisions.

100.3 Grading Rules. Structural timber and lumber used as a permanent part of a structure shall be graded, in accordance with the grading rules adopted by the regional association of the lumber manufacturers which conform to the basic provisions of the "American Lumber Standards."

100.4 Inspection Certificates. Inspection certificates shall be furnished without extra charge with each shipment of timber or lumber. These inspection certificates shall be issued by one of the following lumber inspection bureaus:

West Coast Bureau of Lumber Grades and Inspection
Pacific Lumber Inspection Bureau
Port Orford Cedar Association
California Redwood Association, or
Western Pine Association.

SECTION 101—TIMBER PILES

101.1 Material Covered. This specification covers the quality of timber piles.

101.2 Species of Wood. Foundation piles which will be below water level at all times may be of any species of wood which, in the opinion of the engineer, will satisfactorily withstand driving. This type of piling shall be used only when specifically noted on the plans or ordered by the engineer.

Treated and untreated piles preferably shall be of coast region Douglas fir.

101.3 Quality. All wood piling shall be cut from sound and live trees, preferably during the winter season. They shall contain no unsound knots. Sound knots will be permitted, provided the diameter of the knot does not exceed four inches or one-third of the diameter of the stick at the point where it occurs. Any defects or combination of defects which will impair the strength of the pile more than the maximum allowable knot shall not be permitted. The butts shall be sawed square, and the tips shall be sawed square or tapered to a point not less than four inches in diameter as directed by the engineer.

Unless otherwise specified, all piles shall be peeled by removing all of the rough bark and at least 80 percent of the inner bark. No strip of inner bark remaining on the stick shall be over three-quarters inch wide or eight inches long, and there shall be at least one inch of clean wood surface between any two such strips. Not less than 80 percent of the surface of any circumference shall be clean wood.

Piles shall be cut above the ground swell and shall taper from butt to tip. A line drawn from the center of the tip to the center of the butt shall not fall outside of the center of the pile at any point more than one percent of the length of the pile. In short bends, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend shall not exceed four percent of the length of the bend or a maximum of two and one-half inches. All knots shall be trimmed close to the body of the pile.

101.4 Dimensions. Round piles shall have a minimum diameter at the tip, measured under the bark as follows:

Length of pile	Tip diameter
Less than 40 feet	8 inches
40 to 60 feet	7 inches
Over 60 feet	6 inches

The minimum diameter of piles at a section three feet from the butt, measured under the bark, shall be as follows:

Length of pile	DIAMETER IN INCHES	
	Douglas fir	All other species
20 feet and under	11	11
21 to 30 feet	12	12
31 to 40 feet	12	13
Over 40 feet	13	14

The diameter of the pile at the butt shall not exceed 20 inches.

Square piles shall have the dimensions shown on the plans.

101.5 Preservative Treatment. Preservative treatment when required, shall conform to Section 63 of these specifications.

101.6 Inspection. Each shipment of piles shall be accompanied by an inspection certificate issued by the West Coast Bureau of Lumber Grades and Inspection, the Pacific Lumber Inspection Bureau, or by any recognized commercial inspector approved by the engineer prior to inspection, certifying that each pile meets the quality and requirements specified herein. The cost of inspection certificates shall be included in the price paid for the piles.

When treated piles are required, the contractor shall inform the engineer of the name of the plant at which the piles are to be treated, sufficiently far in advance of starting the work so that arrangements may be made for inspection. The contractor shall furnish facilities for the inspection of material and workmanship, and the inspector shall be allowed free access to the necessary parts of the plant. The cost of inspection of creosote treatment shall be borne by the department.

SECTION 102—TIMBER PRESERVATIVE

102.1 Material Covered. This specification covers the quality of creosote oils, creosote coal tar solution, and creosote petroleum solution for use as timber preservative.

102.2 Preservatives. Preservatives used shall be as specified or directed by the engineer and shall be one of the following, depending on the type of treatment: Creosote oils shall be a distillate of coal gas tar or coke oven tar. Creosote-coal tar solution shall be a coal tar product of which at least 80 percent shall be a distillate of coal gas tar or coke oven tar, and the remainder shall be refined or filtered coal gas tar or coke oven tar. Creosote and creosote coal tar solution shall conform to the following specifications:

	Creosote	Creosote coal tar solution
1. It shall not contain water in excess of.....	3.0%	3.0%
2. It shall not contain matter insoluble in benzol in excess of. (See Note.).....	0.5%	2.0%
3. The specific gravity at 38°/15.5° C. shall not be less than.....	1.03	1.05
Nor more than.....	.....	1.12
4. The distillate based on water-free oil shall be within the following limits :		
Up to 210° C., not more than.....	5.0%	5.0%
Up to 235° C., not more than.....	25.0%	25.0%
5. Coke residue of oil shall not exceed.....	2.0%	6.0%

NOTE—Samples of creosote or creosote-coal tar solution taken from working tanks may show an increase in matter insoluble in benzol due to treating operations. Such increases, provided they do not exceed by one percent the specification limits, should not serve to cause rejection of the creosote for nonconformity with specifications if it can be shown that the original fresh oil was of specified quality.

Creosote petroleum solution shall have the following properties :

(a) It shall contain not less than 50 percent by volume of coal tar creosote as specified above.

(b) It shall contain not more than 50 percent by volume of petroleum that meets the following requirements :

(c) The specific gravity of the petroleum at 60° F. compared with water at 60° F. shall not be less than 0.96 (not greater than 15.9° A. P. I.) (A. S. T. M. Standard D-287.)

(d) The water and sediment (B. S. W.) shall not be more than one percent. (A. S. T. M. Standard D-96.)

(e) The flash point shall not be less than 215° F. as determined by the Pensky-Martens closed tester. (A. S. T. M. D-93.)

(f) The viscosity of the petroleum shall not be less than 40 and preferably not over 60 Sayboldt Universal seconds at 210° F., although petroleum of higher viscosity may be used if the penetration requirements of specifications covering treatment details are met. (A. S. T. M. D-88.)

(g) Tests required in paragraphs (c), (d), (e), and (f) shall be made in accordance with the Standard Methods of A. S. T. M.

102.3 Sampling and Testing. Creosote oils and creosote-coal tar solutions shall be sampled and tested in accordance with the Method of Sampling and Analysis of Creosote Oil, A. A. S. H. O., T-60.

Coke residue shall be determined in accordance with the Method of Test for Coke Residue of Creosote Oil, A. A. S. H. O., T-61.

SECTION 103—FENCE POSTS AND FENCE MATERIALS

103.1 Material Covered. This specification covers the quality of fence posts, wire fencing, and gates.

103.2 Split Redwood Line and Brace Posts. Split redwood posts shall be sound live timber free from bark, decay, splits, large or numerous knots, or knot holes, etc., that will impair their strength or durability. Line posts shall be seven feet long with a perimeter of not less than 17 inches. They shall be approximately four inches by five inches in cross section. The posts shall be cut square on both ends.

103.3 Redwood Gate, End, and Corner Posts. Redwood gate, end, and corner posts and braces for such posts shall be 1000#^c close-grained redwood structural posts and timbers conforming to the requirements of Section 100.

103.4 Split Cedar Line and Brace Posts. Split cedar posts shall be sound, live timber free of bark, decay, splits, large or numerous knots, etc., that will impair their strength or durability. The minimum perimeter at any point shall not be less than 18 inches. Line posts shall be seven feet in length.

103.5 Douglas Fir Gate, End, and Corner Posts. Douglas fir gate, end, and corner posts, and braces for such posts shall be 1100#^c Douglas fir structural posts or timbers conforming to the requirements of Section 100.

The lower three feet of these posts shall be dipped in hot creosote or creosote coal tar solution and allowed to remain in the hot liquid not less than five minutes, or painted with not less than two field coats of an approved wood preservative.

103.6 Metal Line Posts. Metal line posts shall be iron or steel of "L," "T," "I," or other approved shape weighing not less than 1.4 pounds per linear foot, and shall be painted light grey. Posts shall be provided with slots, lugs, hooks, or other suitable devices to hold the wire firmly in position. All metal posts shall be seven feet long.

103.7 Metal Gate, End, Corner, and Brace Posts. Metal gate, end, corner, and brace posts shall be of iron or steel,

tubular in section, not lighter than number eight gage, two and one-half inches in diameter, and galvanized.

103.8 Barbed and Woven Wire and Staples. Barbed wire shall be two point galvanized barbed wire weighing approximately 312 pounds per mile. It shall consist of two strands of $12\frac{1}{2}$ gage wire twisted with 14 gage barbs spaced five inches apart. The wire and the staples used to secure it shall conform to the requirements of A. S. T. M., A-121. Woven wire shall have continuous vertical stays not more than 12 inches apart. The top and bottom wire shall be not lighter than 10 gage and intermediate wires and stays not lighter than $12\frac{1}{2}$ gage.

103.9 Metal Gates. Metal gates shall have galvanized tubular steel frames not less than 54 inches high filled with not lighter than nine gage galvanized woven wire fabric.

103.10 Timber Gates. Timber gates shall be constructed of redwood or Douglas fir conforming to the requirements of Section 100.

SECTION 104—GUARD RAIL MATERIALS

104.1 Material Covered. This specification covers the quality of metal guard rail plates and spring supports.

104.2 General Requirements. Before any type rail is used, the manufacturer's plans and specifications shall be submitted and approved by the engineer, and the rail shall be constructed in accordance with such plans, except as herein provided. Plans shall show full details of all assemblies.

104.3 Nonfloating Type Rail. Rail plates shall be rolled from steel conforming to the following requirements:

Carbon.....	0.40 to 0.60%
Manganese.....	0.30 to 0.90%
Phosphorus, max.....	0.055%
Sulphur, max.....	0.055%

Plates shall be properly tempered for toughness and shall have a tensile strength of not less than 75,000 pounds per square inch.

The rail plates shall not be less than 12 inches wide, nor lighter than No. 14 gage, and shall be rolled or rounded so as to present no sharp edges. All connections and splices shall be made with flat, round-headed bolts or other similar details so that no appreciable projection will obstruct a vehicle sliding along the rail.

An offset bracket shall support the rail element five to six inches from the face of the post and shall be rounded and springlike on the outer face. It shall deflect at least one inch under a compression of 4,500 pounds perpendicular to the line of the rail and shall, upon release of this load held for one minute, show a permanent set of not greater than five percent of the measured deflection. It shall not collapse under a compression of 9,000 pounds. The bracket and connection to the post combined shall be capable of supporting a horizontal load of 4,500 pounds at the rail parallel to the rail.

The resilient detail at or near the end post shall completely deform or take up when the rail is placed under a tension of not less than 3,000 nor more than 5,000 pounds. It shall not take a permanent set greater than five percent

of the total deformation under a rail tension of 23,000 pounds held for one minute, and shall not collapse under a rail tension of 70,000 pounds.

The connection between the rail and end posts shall have an ultimate tensile strength of 70,000 pounds, and when subjected to a tensile stress of 23,000 pounds held for one minute, shall not take a permanent set greater than five percent of the deformation. The connection shall consist of at least two bolts, and the eccentricity between bolt and plate shall not be greater than two inches.

104.4 Floating Type Rail. Rail plates shall be rolled from steel conforming to the following requirements:

Carbon.....	0.40 to 0.60%
Manganese.....	0.30 to 0.90%
Phosphorus, max.....	0.055%
Sulphur, max.....	0.055%

The plates shall be properly tempered for toughness and shall have a tensile strength of not less than 75,000 pounds per square inch.

Spring supports shall be rolled from steel conforming to the following requirements:

Carbon.....	0.60 to 0.80%
Manganese.....	0.30 to 0.90%
Phosphorus, max.....	0.055%
Sulphur, max.....	0.055%

The supports shall be tempered to give a tensile strength of not less than 135,000 pounds per square inch.

The rail plates shall not be less than 12 inches wide nor lighter than No. 14 gage, and shall be rolled or rounded so as to present no sharp edges. Connections and splices shall be made with flat, round-headed bolts or other similar detail so that no appreciable projection will obstruct a vehicle sliding along the rail.

End spring assemblies for floating type rail shall consist of at least two springs. The eccentricity between springs and plate shall not be greater than three inches. The springs shall close at least four inches under a total tension in the rail of 7,500 pounds. The spring assembly shall have an ultimate tensile strength of 70,000 pounds, and under a rail tension of 23,000 pounds held for one minute shall not

take a permanent set greater than five percent of the deformation.

The connection between the end springs and end posts shall consist of at least two bolts, and shall have an ultimate tensile strength of 70,000 pounds.

104.5 Beam Type Rail. Rail plates shall be rolled from steel conforming to the following requirements:

Carbon.....	0.40 to 0.50%
Manganese.....	0.50 to 0.80%
Phosphorus, max.....	0.045%
Sulphur, max.....	0.055%

The plates shall be properly tempered for toughness, and shall have a tensile strength of not less than 85,000 pounds per square inch.

Spring supports shall be rolled from steel conforming to the following requirements:

Carbon.....	0.90 to 1.05%
Manganese.....	0.25 to 0.50%
Phosphorus, max.....	0.040%
Sulphur, max.....	0.050%

The supports shall be tempered to give a tensile strength of not less than 100,000 pounds per square inch.

The plates shall be shaped into a beam not less than 12 inches wide and not less than one inch deep. Where the plate is corrugated or shaped into any other form and the depth as a horizontal beam perpendicular to the line of the rail is three inches or more, the thickness of metal shall be at least 10 gage. Where this depth is less than three inches, the thickness of metal shall be at least nine gage. The rail element shall be spliced at each post by lapping in the direction of traffic. The holes in the plate farthest from the travelled way shall be slotted to facilitate erection and to permit expansion. The splice for beams three inches or more in depth shall have an ultimate tensile strength of 30,000 pounds. The splice for beams less than three inches in depth shall have an ultimate tensile strength of 45,000 pounds.

The edges of the rail shall be rolled or rounded so that they present no sharp edges. The projecting heads of all connections and splice bolts shall be rounded and shallow

so that no appreciable projection shall obstruct a vehicle sliding along the rail. Each end of each length of rail shall be finished with a section of rail bent or turned so that the end shall be in line with the back face of the end post. These end pieces shall be of the same metal as the rail element and shall be spliced with it as at any other post.

Beams shall be supported five to six inches from the face of the post with a springlike bracket which shall deflect at least one inch under a load of 4,500 pounds perpendicular to the line of the rail, and shall, upon release of this load when held for one minute, show a permanent set not greater than five percent of the measured deflection. It shall not collapse under a compression of 9,000 pounds. The bracket and connection to the post combined shall support a load of 3,000 pounds at the rail parallel to the rail.

104.6 Mill Test Reports. Two certified copies of mill test reports showing the chemical and physical characteristics from each heat from which metal is used shall be furnished by the contractor.

104.7 Test Specimens. Upon request the contractor shall furnish the engineer with specimens of rail, plates, and fittings for testing purposes, free of charge.

SECTION 105—EXPANSION JOINT FILLER

105.1 Material Covered. This specification covers pre-molded expansion joint filler for concrete. It may be either of the nonextruding and resilient type or of the bituminous fiber type.

105.2 General Requirements—

NONEXTRUDING AND RESILIENT TYPES

CORK AND SELF-EXPANDING CORK. These types shall consist of preformed strips which have been formed from clean granulated cork particles securely bound together by an insoluble synthetic resin. The granulated cork shall be reasonably free from hard particles or dust and shall not have been exposed in the process of manufacture to a temperature exceeding 300° F.

SPONGE RUBBER. This type shall consist of preformed strips composed essentially of a durable elastic rubber compound which may be reinforced on each side with a layer of asphalt treated felt which has been bonded to the rubber compound filler under heat and pressure.

CORK RUBBER. This type shall consist of preformed strips which have been formed from clean granulated cork particles securely bound together by a durable elastic rubber compound.

BITUMINOUS FIBER JOINTS

This type shall consist of preformed strips which have been formed from cane or other suitable fiber of a cellular nature securely bound together and uniformly impregnated with a suitable asphaltic binding.

Preformed strips of expansion joint filler shall be of such character as not to be deformed or broken by twisting, bending, or other ordinary handling after having been subjected 12 hours to a temperature of 125° F. or when subjected to freezing temperatures.

105.3 Dimensions. Dimensions shall be as specified or shown on the plans and tolerances of plus one-sixteenth inch thickness, plus or minus one-eighth inch depth and plus or minus one-quarter inch length shall be permitted.

105.4 Sampling and Testing. A sample of each thickness of joint filler shall be submitted from each shipment

of 1,000 linear feet or less and shall consist of a representative section at least two feet in length and the full depth of the joint.

Testing of premolded expansion joint filler shall be in accordance with the A. A. S. H. O. Standard Method T-42. Nonextruding and resilient types shall meet the requirements of A. A. S. H. O. Specification M-58. Bituminous fiber type shall meet the requirements of A. A. S. H. O. Specification M-59.

SECTION 106—PAINTS AND PAINT MATERIALS

106.1 Materials Covered. These specifications cover paint and paint materials for use on steel, timber, and other materials.

Paint may be furnished ready-mixed, or individual components may be combined on the job prior to use, in the presence of the engineer.

Paint shall be well mixed in the manufacture by proper grinding of the pigment. The pigment shall not settle badly or cake in the container, shall not thicken in storage to cause change in consistency, and shall be readily broken up with a paddle to a smooth, uniform condition, capable of easy application with a brush or mechanical distributor in the ordinary manner according to the rules of good standard practice.

106.2 Certified Analysis and Guarantee. The contractor furnishing paint under these specifications shall furnish without additional charge a certified copy of the analysis of each shipment of paint and a manufacturer's guarantee, which shall provide that the paint conforms to the certified analysis. This guarantee shall be sworn to by a person having legal authority to bind the manufacturer by his acts. He shall, in addition, furnish without charge representative samples of the paint for confirmatory tests.

106.3 Red Lead. Red lead shall conform to the requirements of standard specifications for red lead, serial designation D-83 of the A. S. T. M. It shall be 95 percent grade.

106.4 White Lead. White lead shall conform to the requirements of standard specifications for basic carbonate white lead, serial designation D-81 of the A. S. T. M.

106.5 Zinc Oxide. Zinc oxide shall conform to the requirements of standard specifications for zinc oxide, serial designation D-79 of the A. S. T. M.

106.6 Raw Linseed Oil. Raw linseed oil shall conform to the requirements of standard specifications for raw linseed oil, serial designation D-234 of the A. S. T. M.

106.7 Boiled Linseed Oil. Boiled linseed oil shall conform to the requirements of standard specifications for boiled linseed oil, serial designation D-260 of the A. S. T. M.

106.8 Turpentine. Turpentine shall conform to the requirements of standard specifications for spirits of turpentine, serial designation D-13 of the A. S. T. M.

106.9 Liquid Drier. Liquid drier shall conform to the requirements of standard specifications for liquid paint drier, serial designation D-600 of the A. S. T. M. Class B drier shall be furnished.

106.10 Spar Varnish. Spar varnish shall conform to the requirements of Federal Specification TTV-81a, Mixing Varnish for Aluminum Paint.

106.11 Aluminum Powder for Paint. Aluminum powder for paint shall conform to the requirements for standard specifications for aluminum powder for paints, serial designation D-266 of the A. S. T. M.

106.12 Lamp Black. Lamp black paste in oil shall conform to the requirements of standard specification for lamp black, serial designation D-209 of the A. S. T. M.

106.13 Carbon Black. Carbon black shall conform to the requirements of standard specifications for carbon black, serial designation D-561 of the A. S. T. M.

106.14 Prussian Blue. Prussian blue shall conform to the requirements of standard specifications for prussian blue, serial designation D-261 of the A. S. T. M.

106.15 Aluminum Paste. Aluminum paste shall consist of aluminum powder conforming to the requirements set forth above, ground to form a paste with a liquid completely volatile at 225° F. The paste shall contain not less than 65 percent by weight of metallic aluminum, of 99 percent purity.

There shall be no appreciable settlement of the metallic portion of the paste in the container and no free liquid shall be present. When mixed with spar varnish in proportions of two and one-quarter pounds of paste to one gallon of vehicle, the resulting paint shall have satisfactory leafing properties, and shall give a free flowing, smooth, continuous coating free from breaks or sags.

106.16 Titanium Dioxide Pigment. Unless otherwise specified titanium dioxide pigment shall be titanium-barium pigment, class A or B conforming to the standard

specifications for titanium dioxide pigment, serial designation D-476 of the A. S. T. M.

106.17 Tung Oil. Tung oil shall conform to the requirements of standard specifications for raw tung oil, serial designation D-12 of the A. S. T. M.

106.18 Butanol. Butanol (normal butyl alcohol) shall conform to the requirements of standard specifications for butanol, serial designation D-304 of the A. S. T. M.

106.19 Acetone. Acetone shall conform to the requirements of the standard specifications for acetone, serial designation D-329 of the A. S. T. M.

106.20 Medium Chrome Yellow. Medium chrome yellow shall conform to the requirement of standard specifications for chrome yellow, serial designation D-211 of the A. S. T. M.

106.21 Inert Materials. Inert materials used in paint for timber shall be silica or asbestos pulp. Silica shall be ground from rock crystal and water floated; it shall be 98 percent pure silica and 98 percent shall pass the No. 325 mesh sieve. Asbestos pulp shall be white in color; it shall not contain more than eight percent of lime as calcium oxide nor shall the loss on ignition exceed 12 percent.

106.22 Paint Formulas. Unless otherwise specified paint shall conform to the following formulas. NOTE—Wherever a white pigment is specified in these formulas pure white lead may be substituted with the approval of the engineer.

FORMULA A—PRIMER

Structural Steel and Metal Parts—Required unless otherwise specified.

Pigment.....	81% (by weight)
Vehicle.....	19% (by weight)

Composition of Pigment

Red lead.....	100% (by weight)
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Composition of Vehicle

Raw linseed oil.....	84 to 92% (by weight)
Drier.....	4% (by weight)
Turpentine.....	4 to 12% (by weight)

FORMULA B—SECOND COAT

Structural Steel and Metal Parts—Required unless otherwise specified.

Pigment.....	77% (by weight)
Vehicle.....	23% (by weight)

Composition of Pigment

Red lead.....	99.8% (by weight)
Carbon black.....	0.2% (by weight)

Composition of Vehicle

Raw linseed oil.....	87 to 94% (by weight)
Drier.....	3% (by weight)
Turpentine.....	3 to 10% (by weight)

FORMULA C—THIRD COAT

Structural Steel and Metal Parts—To be used only when specified.

Pigment.....	68% (by weight)
Vehicle.....	32% (by weight)

Composition of Pigment

White lead.....	80% (by weight)
Zinc oxide.....	20% (by weight)

Composition of Vehicle

Raw linseed oil.....	94% (by weight)
Drier.....	3% (by weight)
Turpentine.....	3% (by weight)

FORMULA D—PRIMER

New Timber or Old Timber with Paint in Good Condition—Required unless otherwise specified.

Pigment.....	61% (by weight)
Vehicle.....	39% (by weight)

Composition of Pigment

White lead.....	80% (by weight)
Zinc oxide.....	20% (by weight)

Composition of Vehicle

Raw linseed oil.....	73.5% (by weight)
Drier.....	1.5% (by weight)
Turpentine.....	25% (by weight)

FORMULA E—PRIMER

Old Seasoned Timber—To be used only when specified.

Pigment.....	58% (by weight)
Vehicle.....	42% (by weight)

Composition of Pigment

White lead.....	80% (by weight)
Zinc oxide.....	20% (by weight)

Composition of Vehicle

Raw linseed oil.....	98.5% (by weight)
Drier.....	1.5% (by weight)

FORMULA F—SECOND AND THIRD COATS

Timber—Second coat required; third coat to be used only when specified.

Pigment.....	64% (by weight)
Vehicle.....	36% (by weight)

Composition of Pigment

White lead.....	70% (by weight)
Zinc oxide.....	20% (by weight)
Inert material.....	10% (by weight)

Composition of Vehicle

Raw linseed oil.....	90% (by weight)
Drier.....	5% (by weight)
Turpentine.....	5% (by weight)

FORMULA G—SECOND AND THIRD COATS OPTIONAL WITH FORMULA F

Pigment.....	66% (by weight)
Vehicle.....	34% (by weight)

Composition of Pigment

Titanium dioxide pigment.....	35% (by weight)
White lead.....	45% (by weight)
Zinc oxide.....	20% (by weight)

Composition of Vehicle

Raw linseed oil.....	92% (by weight)
Drier.....	4% (by weight)
Turpentine.....	4% (by weight)

FORMULA H—THIRD COAT

Steel and Timber—Required unless otherwise specified; optional with Formula I.

Aluminum powder.....	2 pounds
Spar varnish.....	1 gallon

FORMULA I—THIRD COAT

Steel and Timber—Required unless otherwise specified; optional with Formula G.

Aluminum paste.....	2½ pounds
Spar varnish.....	1 gallon

FORMULA J—THIRD COAT

Timber, Black Bands, Etc.—Culvert Markers and Guide Posts, Etc.—Required unless otherwise specified.

Pigment.....	30% (by weight)
Vehicle.....	70% (by weight)

Composition of Pigment

Red lead.....	8% (by weight)
Carbon black.....	22% (by weight)
Inert material.....	70% (by weight)

Composition of Vehicle

Raw linseed oil.....	80% (by weight)
Drier.....	10% (by weight)
Turpentine.....	10% (by weight)

FORMULA K—WHITE TRAFFIC LACQUER

The lacquer shall be mixed at the factory and shall dry so that it will not tack in from 15 to 30 minutes.

Solvent

Raw tung oil.....	15% (by volume)
Butanol.....	17% (by volume)
Acetone.....	34% (by volume)
Denatured alcohol, Formula No. 1.....	34% (by volume)

The butanol, acetone, and denatured alcohol shall be mixed and then the tung oil added to form a clear solution at 70° F.

Gum Vehicle

Gum (East Indian D. B. B. Boca)....	34 to 37% (by weight)
Solvent (as above).....	63 to 66% (by weight)

Pigment

Titanium dioxide.....	25 to 30% (by weight)
Barium sulphate.....	70 to 75% (by weight)

Lacquer

Titanium barium pigment.....	42 to 45% (by weight)
Gum vehicle (as above).....	55 to 58% (by weight)

NOTE—Sufficient Prussian blue shall be added to overcome the yellowish tint. The volatile material shall have a minimum solvent action on asphalt and shall be of such nature that the gums and nonvolatile components will entirely dissolve therein and will not precipitate on standing. The nonvolatile matter shall be of such quality that it will not darken or become yellowish when exposed to sunlight in thin sections. Thinner for use with this lacquer or for cleaning the paint spray shall be of the same nature as the volatile vehicles used in manufacturing the lacquer. The thinner shall consist approximately of one part acetone and two parts No. 1 denatured alcohol.

FORMULA L—YELLOW TRAFFIC LACQUER**Gum Vehicle**

Same as for white traffic lacquer.

Pigment

Medium chrome yellow..... 100% (by weight)

Lacquer

Pigment..... 27 to 30% (by weight)

Gum vehicle..... 70 to 73% (by weight)

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